U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 82.
L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

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By F. H. CHITTENDEN, *in Charge of Truck Crop and Stored Product Insect Investigations.*

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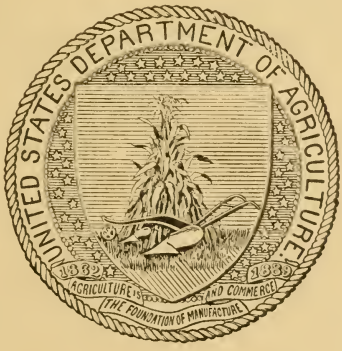

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., August 29, 1912.

Sir: I have the honor to transmit herewith, for publication as Bulletin No. 82, seven papers dealing with certain insects injurious to truck crops. These papers, which were issued separately during the years 1909, 1910, and 1911, are as follows: The Colorado Potato Beetle in Virginia in 1908, by C. H. Popenoe; The Parsnip Leaf-Miner, The Parsley Stalk Weevil, and The Celery Caterpillar, by F. H. Chittenden; The Lima-Bean Pod-Borer and The Yellow-Necked Flea-Beetle, by F. H. Chittenden; The Life History and Control of the Hop Flea-Beetle, by William B. Parker; Biologic and Economic Notes on the Yellow-Bear Caterpillar, by H. O. Marsh; Notes on the Cucumber Beetles, by F. H. Chittenden, and Biologic Notes on Species of Diabrotica in Southern Texas, by H. O. Marsh; Notes on Various Truck-Crop Insects, by F. H. Chittenden.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The present bulletin has been published in parts, seven in number, from time to time as completed, and relates to insects and groups of insects of widely different character. It is in continuation of investigations on insects injurious to truck and vegetable crops begun in 1896, the results of which have been published in Bulletins 19, 23, 29, 33, and 43 and various circulars of this bureau, and in Yearbooks of the Department of Agriculture.

The initial paper, entitled "The Colorado Potato Beetle in Virginia in 1908," is a logical sequel to Circular No. 87, which treats of the same insect in its entire distribution. It furnishes details of experiments made in tidewater Virginia, and gives special instructions for the use of the traction-power sprayer in that region. It also contains interesting notes on the life history and habits of the species for the same region.

Part II gives a consideration of three species injurious to umbelliferous truck crops. The first paper of this part, on the parsnip leaf-miner (*Acidia fratria* Loew), gives a concise account of this insect with some original notes on its biology and suggestions for its control. The second paper, on the parsley stalk weevil (*Listronotus latiusculus* Boh.), gives the results of original observations conducted on this insect in the vicinity of the District of Columbia; indeed, it is the first account of this species which has been published. For the control of this insect, which is only a pest under certain conditions, the abandonment of the culture of parsley is recommended for a short period until the insect disappears. The third article, on the celery caterpillar (*Papilio polyxenes* Fab.) makes no claim to originality, but introduces the first account with good illustrations of this well-known insect which has been published by the Department of Agriculture.

Part III is devoted to two insects injurious to beans and peas. The first of these insects is the lima-bean pod-borer (*Etiella zinckenella* Treit.). The account here given is the first record of the occurrence of this imported insect as a pest in America, although we have reports of injury as far back as 1885. The second article, on the yellow-necked flea-beetle (*Disonycha mellicollis* Say), embodies all the information, recently furnished by agents and correspondents of the bureau, that has been gained in regard to a species which is widely distributed from New York to Texas, especially along the Atlantic coast.

Part IV, on the life history and control of the hop flea-beetle (*Psylliodes punctulata* Melsh.), a species injurious to sugar beet and many vegetable crops, as well as hops, is supplementary to an article on the same species published as Bulletin 66, Part VI. From the standpoint of the occurrence of the insect in British Columbia, where the particular observations were made, the insect is treated in detail with special reference to all of the remedies which have been suggested, leaving little remaining to be learned about the species at the present time.

Part V considers the yellow-bear caterpillar (*Diacrisia virginica* Fab.) in its occurrence in Colorado during 1909. Details of experiments with remedies are furnished, showing that arsenicals were not entirely satisfactory. Additional experiments should be conducted when another outbreak of this species occurs.

The articles which comprise Part VI, namely, "Notes on the Cucumber Beetles" and "Biologic Notes on Species of Diabrotica in Southern Texas," give information in regard to five hitherto little known species of Diabrotica injurious in southern Texas, with observations on two common species—the striped cucumber beetle and the 12-spotted cucumber beetle—in their occurrence in the same region. The papers are chiefly devoted to data in regard to injurious occurrences, food plants, feeding habits, life histories, and the second includes experiments with remedies, arsenate of lead in combination with Bordeaux mixture having furnished good results in the treatment of some of these species.

The bulletin is concluded by Part VII, entitled "Notes on Various Truck-Crop Insects." Under the heading, "On the Natural Enemies of the Colorado Potato Beetle," four unrecorded insect enemies are treated, a list of wild bird enemies is referred to, the chipping sparrow is added as a new enemy, and attention is directed to the efficacy of the guinea fowl in the destruction of the potato beetle. Notes on the potato stalk weevil include a note showing that *Trichobaris trinotata* Say may, at least exceptionally, pass the winter as larva or pupa instead of as beetle. Mention is made of three species of maggots previously unrecorded as affecting yams. The gregarious habit of some common blister beetles is described and mention is made of an effective method of destroying them, namely, by dislodging them from the plants attacked into pails in which kerosene is floating on water.

F. H. Chittenden,
In Charge of Truck Crop and Stored Product Insect Investigations.

CONTENTS.[a]

[a] The seven parts constituting this bulletin were issued in separate form on July 28, November 30, and December 28, 1909; May 20, August 31, and December 8, 1910; and February 18, 1911, respectively.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

U. S. D. A., B. E. Bul. 82, Part 1. Issued July 28, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE COLORADO POTATO BEETLE IN VIRGINIA IN 1908.

By C. H. Popenoe, *Agent and Expert.*

[In cooperation with the Virginia Truck Experiment Station.]

INTRODUCTION.

The tidewater region of Virginia, which comprises Norfolk, Princess Anne, Nansemond, and Isle of Wight counties on the western and southern, and Northampton and Accomac counties on the eastern shore of the Chesapeake Bay, is probably the greatest center for the production of early potatoes in the eastern United States. The value of the potato crop shipped from these counties approaches $6,000,000 annually. Two crops are raised over a small portion of this area, while over the greater part, including the counties of Norfolk and Princess Anne, only a single planting is made, the potatoes being planted during the latter part of February and the first of March, and the crop of new potatoes being harvested in June. As this crop is not carried through to maturity, new potatoes being the desired product, the action of the late blight is not apparent until the crop is ready to harvest and is, therefore, given little consideration as a pest. As the early blight does little injury to the plants, the Colorado potato beetle (*Leptinotarsa decemlineata* Say) becomes the worst drawback to the culture of the potato in this locality. The long growing season and the inefficient methods employed for the control of this insect pest afford it an unusual opportunity for injury over a wide area. In only a few cases are effective methods of application practiced, and for this reason demonstration and experimental work have been thought advisable for the locality.

STATUS OF THE POTATO BEETLE IN VIRGINIA.

Owing to the employment of negro labor and the scarcity of capable white help the methods for the control of the potato beetle over this area are necessarily crude. While the insects are in hibernation no effort is made for their destruction, the first attempt to control the species being the hand picking of hibernated beetles from the vines

by negro children. Afterwards the vines are dusted with land plaster and Paris green, applied by shaking a burlap sack, filled with the mixture, over the plants which seem to be the worst affected. As a result of the imperfect application of the arsenical the crop is only partially freed from the insects and, as the application is never made until the injury of the first generation or brood of larvæ becomes very apparent, the vines are not entirely free from the injurious effects of untimely defoliation. In many places, also, the plants are seriously checked through the injury caused by the beetles, which entirely defoliate the young shoots as they are coming through the earth, in many cases eating them off level with the ground or below the surface. Seed potatoes which remain partially above ground are also rapidly devoured by the beetles.

After the larvæ or young commence to appear, the plants showing the greatest injury are treated with the dust, this application usually being held sufficient for some time. The land-plaster application is from three to four times as expensive as a Paris-green spray of equal strength, and in several cases in the Norfolk region the application of the unnecessary plaster to the already acid soil has produced a state of disease in the cabbage crop following the potatoes which has lessened the production to a considerable degree. In the case of a spray this acidity is not imparted to the soil and injury to cabbage is thus avoided.

In that part of Virginia immediately adjacent to the District of Columbia the growing of potatoes is less important commercially than in the Norfolk region, and while the beetle is a serious pest always, the smaller acreage of potatoes grown renders the control of the insect much more easily accomplished.

LIFE HISTORY AND HABITS.

In general, the life history of the Colorado potato beetle in Virginia agrees with the description already published by Doctor Chittenden.[a] In specimens reared in confinement in the insectary at Washington and in outdoor cages at Norfolk in 1908, three generations or broods were reared during the summer, and very young larvæ have been seen on tomato at Norfolk as late as the latter part of August and the 1st of September. The period of æstivation which generally follows the second generation in this species was shortened to four days in the beetles which were carried through the stages at Norfolk. These beetles issued from eggs collected from the first generation May 26. The larvæ pupated June 20 and issued as adults June 28. After feeding until July 3 the beetles burrowed into the soil, forming cells, where they remained for a period of four days,

[a] Cir. No. 87, Bur. Ent., U. S. Dept. Agr., 1907.

FIG. 1.—THE COLORADO POTATO BEETLE (LEPTINOTARSA DECEMLINEATA) ATTACKING SEED POTATO IN GROUND, CHURCHLAND, VA. (ORIGINAL.)

FIG. 2.—YOUNG POTATO PLANT DEFOLIATED BY COLORADO POTATO BEETLES.

Twenty beetles sometimes on plants this size. Nearly natural size. (Original.)

coming after this time to the surface, where the third generation of eggs was deposited three days later. Owing to a scarcity of proper food at this time this third generation was not well cared for, and as only three mutilated specimens reached maturity the experiment was closed. This record, however, verified the existence of a third generation, concerning which there has been some doubt.

The beetles issue from hibernation in the soil, where they pass the winter in the adult stage, some time during the first two weeks of April, as the earliest potato plants begin to appear above the soil, and begin to feed upon these young shoots before producing eggs, which, however, are soon deposited. In many cases from six to twelve beetles may be seen on a single plant, which is likely to be completely defoliated if not entirely destroyed. As many as 20 beetles are sometimes seen on a single shoot, and where they occur in such numbers the plant is very apt to be eaten off close to the ground if, indeed, the beetles do not follow the stem into the earth. It is at this time that the attack of the adults is most severe and the plant is greatly weakened by such injury. (See Pl. I.)

After the plants reach a considerable size the damage done by the larvæ becomes most apparent, large plants being defoliated. At this time the poison is usually applied to the plants showing the greatest injury and a majority of the larvæ are destroyed.

The beetles which pass through the winter are usually those of the third generation. These seem to do very little injury to the second crop of potatoes, which is generally quite free from damage and rarely needs treatment for insect attack. It would thus appear that the beetles coming from this generation hibernate after the first crop with but few exceptions and remain in hibernation until the following year. A few of the beetles may be seen occasionally upon second-crop and volunteer potatoes, but no eggs are deposited, the entire injury being accomplished by the adults. Unquestionably many of these perish during the long period of hibernation and, on warm spring days with an offshore wind, great numbers of the hibernated individuals are blown or carried out to sea, where they perish, the beach after such a time being frequently covered with windrows of the dead beetles.[a] Notwithstanding these facts, a sufficient number survives to make the insect the pest that it is, although the destruction in this manner must serve as a temporary check to the increase of the species.

INSECT ENEMIES.

The insect enemies of the potato beetle were very little in evidence in tidewater Virginia during the season of 1908. *Podisus maculiventris* Say was noted and the usual tachinid parasitization was

[a] This statement is substantiated by similar observations by Dr. A. D. Hopkins and Mr. E. A. Schwarz, of the Bureau of Entomology.

present, but at a very low figure, eggs being seen on only 3 to 4 per cent of the larvæ. Harpaline ground-beetles were abundant and *Lebia grandis* Hentz was undoubtedly a factor in keeping down the great increase of the potato beetle.

REMEDIES.

With regard to remedies, a considerable number of experiments was performed with a view to discovering the cheapest and most effective insecticide for controlling the potato beetle. Several plats, consisting of one-tenth of an acre each, were prepared for testing the effects of the poisons on the plants and on the larvæ. An insight into the methods of research by which the results were obtained may be of value to the investigator, and a somewhat detailed account of the experiments with insecticides is given.

EXPERIMENTS WITH INSECTICIDES.

A plat of about 1½ acres was selected early in the season and planted to potatoes, a single variety being used. The plat was divided into rows of such a length as to contain one-fortieth of an acre, four of these rows constituting a test plat of one-tenth of an acre. The plat was allowed to become thoroughly infested by beetles and larvæ in several stages. The various plats were then numbered and treated with the different insecticides. The fertilizer treatment was the same in all cases, and as the ground on which the potatoes were planted was new, the yield could not have been affected by a residue of fertilizer remaining in the soil from the previous year. The poisons were applied with a knapsack sprayer.

Experiment No. 1.—One-half pound white arsenic and 2 pounds sal soda were boiled together in one-half gallon of water until dissolved. The mixture was used in the proportion of 1 pound of arsenic to 50 gallons of water, with the addition of 6 pounds of lime per 50 gallons of solution, and was applied about 10 a. m.

Twenty-four hours after spraying, the plat was examined and no living beetles or larvæ could be found. At this time no damage to the foliage was apparent as a result of the arsenic, but two days later the potatoes showed extensive burning and scalding. The foliage was almost entirely killed by this application, and some time was required for the plants' recovery.

Arsenic in this form is a very cheap insecticide but, on account of its effect on the plants, could not be used, although extremely effective in destroying the leaf-feeding insects.

Experiment No. 2.—Commercial arsenate of lead was applied with Bordeaux mixture. Five pounds arsenate of lead paste with 4 pounds of copper sulphate and 6 pounds fresh lime were used in 50 gallons of water. The day was bright and clear with a southwest wind and a temperature of 85° F.

Examination the following day showed no living larvæ present on the vines. A small number of dead larvæ still clung to the stems in some places. No injury to the foliage was seen nor did any afterwards appear.

Experiment No. 3.—Arsenate of lead was applied at the rate of 6 pounds to 50 gallons of water. The day was bright, with a temperature of 87° F. and a southwest breeze.

An application of this strength resulted in destroying 85 to 90 per cent of the larvæ in twenty-four hours, and all of the larvæ in forty-eight hours. No injury as a result of the poison was seen at this time or later.

Experiment No. 4.—For this plat, Paris green without lime was used at the rate of 4 pounds to 50 gallons of water. The weather was as in Experiment No. 3.

Twenty-four hours later the mortality of the larvæ had reached 80 to 85 per cent. The remainder of the larvæ were in a dying condition and no damage to the vines was noted at this time as a result of the arsenic. By the next day, however, some traces of burning were to be seen although not of a serious nature. The larvæ were by this time thoroughly exterminated on the plat.

Experiment No. 5.—This plat was sprayed with a Paris-green mixture, consisting of 3 pounds of Paris green with Bordeaux mixture, composed of 4 pounds copper sulphate, 6 pounds of lime, and 50 gallons of water. The day was bright, with a temperature of 85° F. The mixture was applied thoroughly and remained on the leaves well.

An examination of the plants forty-eight hours after treatment showed no injury to the leaves of the potatoes, while the larvæ had succumbed to the poison, the vines being completely cleared.

Experiment No. 6.—This plat was treated with a mixture of Paris green and land plaster at the rate of 1 pound of Paris green to 50 pounds of plaster, the mixture being put in a coarse burlap bag and sifted over the plants by a negro laborer in the usual plantation manner, the amount of dust used being at the rate of 320 pounds per acre. The wind prevailing at the time carried a large part of the dust from the plat as it was applied, but the portion remaining was sufficient to thoroughly destroy the larvæ by forty-eight hours afterwards.

This mixture killed 90 per cent of the larvæ during the first twenty-four hours, and is very effective in controlling the potato beetle.

Experiment No. 7.—To this plat Paris green powder was applied, mixed with lime at the rate of 1 pound Paris green to 10 pounds sifted air-slaked lime. The mixture was applied with a powder bellows early in the morning and the application was at the rate of 30 pounds per acre.

Twenty-four hours later all of the larvæ had been destroyed. Extermination was complete, with no injury to the foliage. This mixture seems superior to the plaster mixture used in experiment

No. 6. The application was much more thorough, although barely 10 per cent of the amount of mixture used in the previous experiment was applied. This would greatly lessen the quantity of the acid-producing material, the use of lime as a base for the powdered arsenic tending to correct any acidity in the soil instead of increasing the acid content. Moreover, the cost of this application is much less, as it can be applied at a cost of about $1.20 per acre, while the cost of the usual mixture is about $4.20 per acre. The efficiency of the mixtures is about equal in either case.

Experiment No. 8.—In this plat arsenite of copper was applied at the rate of 4 pounds to 50 gallons of water. The poison was applied without lime. The weather was bright and warm with a northeast wind.

This poison proved equally effective with Paris green used in the same quantity but differed in that no damage to the foliage was noted as a result of the application. The larvæ were entirely destroyed.

Experiment No. 9.—Arsenite of copper, 4 pounds, to 6 pounds of lime in solution with 50 gallons of water was sprayed on this plat. This application was quite effective and at no time produced burning of foliage as an after-effect of the arsenic.

The check plat was severely defoliated by the beetles and larvæ and was undoubtedly injured by the neglect of spraying. The yield of potatoes from this plat was considerably less than that of the properly sprayed plats.

SUMMARY OF EXPERIMENTS.

The following table will show the results of experiments with various insecticides:

No. of experiment.	Date.	Insecticide used.	Effect on plant.	Effect on insect.	Remarks.
1	May 23	Arsenite of lime	Badly burned	Entirely destroyed in 24 hours.	Damage to plants too great to permit its use, although cheapest preparation of those employed.
2	May 27	Arsenate of lead with Bordeaux mixture.	None	Entirely destroyed in 48 hours.	Excellent yield from plat so treated.
3	May 26	Arsenate of lead	do	All killed in 48 hours	Applied at rate of 6 pounds to 50 gallons water.
4	May 26	Paris green without lime.	Slight burning	Very effective	4 pounds to 50 gallons water.
5	May 27	Paris green with Bordeaux mixture.	do	do	3 pounds Paris green to 4–6–50 Bordeaux mixture.
6	May 26	Paris green dust with land plaster.	do	do	4 pounds Paris green to ton land plaster.
7	May 27	Paris green dust with lime.	do	98 per cent destroyed	1 pound Paris green to 10 pounds air-slaked lime.
8	June 17	Arsenite of copper	do	Very effective	4 pounds arsenite of copper to 50 gallons water without lime.
9	June 14	Arsenite of copper with lime.	do	do	4 pounds arsenite of copper with 6 pounds lime to 50 gallons water.
10	May 26	None	Check	Check	Beetles very injurious June 14.

POTATOES GROWING IN NEW GROUND, SHOWING BAR TO EMPLOYMENT OF POWER SPRAYERS. (ORIGINAL.)

THE TRACTION POWER SPRAYER IN USE.

On several occasions a large traction power sprayer, working at a pressure of from 90 to 150 pounds, was used, operating on 5 or 6 rows at a time. The application with this machine was very effective, the plants being thoroughly sprayed above and from below, and were thus completely covered with the mixture. With from 2 to 4 pounds of Paris green to 50 gallons of water this machine did very effective work in the control of the larvæ in large plats of from 30 to 50 acres.

This machine was used for demonstration, as the small sprayers employed in the locality are usually of such a type as to apply the insecticide at a very low pressure; in fact, doing little better than merely sprinkling the upper surface of the vines. It is hoped that the truckers will take advantage of this practical demonstration to the extent of purchasing similar high-grade machines for doing this work. The work done by the traction dust distributors is of value, but on account of the higher cost of the insecticide applied in the form of dust it is desirable that sprayers should replace the dusters, even without considering damage to later crops resulting from the use of land plaster. If lime should replace the plaster in this mixture, at least for a time, the resultant acidity of the soil would be counteracted and more favorable soil conditions would follow, thus preventing fertilizer injury from this source.

The amount of lime distributed by a properly combined spray of Bordeaux mixture or of Paris green with lime is a negligible quantity in any case, while a decidedly beneficial effect is noted as a result of Bordeaux mixture applications, the yield being increased by from 40 to 50 bushels per acre in several experiments conducted by the New York (Geneva) station.[a] Paris green is admitted to possess about one-fourth the fungicidal value of Bordeaux mixture, but applied alone is quite likely to injure the vines, while Bordeaux mixture seems to prevent injury by any arsenical applied with it, even in the case of white arsenic-sal soda mixture. It has also been noted that the potato beetles dislike plants sprayed with Bordeaux mixture and when ready to oviposit leave such plants for those which have not been so treated. Both Paris green and arsenate of lead have yielded very satisfactory results as applications for killing beetles already on the plants, while the Bordeaux mixture acts as a repellent. The cost of material and expense of application for a Paris green or arsenate of lead spray, with Bordeaux mixture, is about 95 cents per acre, while the application of Paris green and land plaster by plantation methods costs nearly $4.20 per acre. The value of the copper unit, one of the active constituents of Bordeaux mixture, as a fungicide

[a] Bull. 290, New York (Geneva) Agr. Exp. Sta., 1907.

develops in the spraying solution but is not freed in the dust application, and, again, the dust does not adhere to the leaves as well as does a liquid application. If arsenate of lead is the insecticide chosen, its adhesive qualities increase its value since it adheres much longer to the foliage in wet weather than has any other mixture yet tested, thus making frequent applications unnecessary.

In the case of newly cleared land, which is frequently planted in potatoes as the first crop, it may be necessary to use a hand sprayer, or even a dusting bag, as the presence of tree stumps (Pl. II) seriously interferes with the effective use of power sprayers, but where possible it is desirable to make use of large machines for spraying, thus lessening the cost of application and increasing to a greater degree the efficiency of the remedial measures. The cost of a good power sprayer, properly equipped for effective work on potatoes, varies from $75 to $125, which amount would easily be saved in the space of one season by the increased yield in the potatoes treated, where a sufficient number of potatoes is grown to justify the employment of a power sprayer. As experiments have shown that treatment at least three times during the growth of the vines is well repaid by the increase in yield, a means of covering the planted areas rapidly and effectively is highly desirable, and the larger spray outfits are well adapted to this work.

CONCLUSION.

In conclusion, it is suggested that at least three thorough applications of Paris green, or arsenate of lead, with Bordeaux mixture be made, the first applied about the time that the first eggs begin to hatch and the later applications at intervals of about three weeks. By this method the beetles should be easily controlled and the injury therefrom almost entirely obviated.

U. S. D. A., B. E. Bul. 82, Part II. Issued November 30, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE PARSNIP LEAF-MINER.

(*Acidia fratria* Loew.)

By F. H. Chittenden, Sc. D.
In Charge of Truck Crop and Stored Product Insect Investigations.

INTRODUCTION.

Since the year 1903 this species, hitherto considered rare, has made its appearance nearly every year in the District of Columbia in such considerable numbers that by July beds of parsnip are found so extensively infested by the maggot or larva that at least 25 per cent of the leaves are sometimes destroyed. The leaves show mines of varying sizes, from that of a dime to others covering the greater portion of a leaf. In 1906 and 1907 the species could not be found in the District of Columbia, but it returned in 1908. A more complete account than has hitherto been available of the insect is herewith presented.

EARLY HISTORY.

Our first knowledge of the existence of this species as an enemy to crop plants was published in 1895 in a short illustrated note by Mr. D. W. Coquillett.[a] At that time it was recorded as having attacked parsnip leaves at Cadet, Mo., in June, 1891. The leaves had been quite extensively mined, and three adults were reared June 23, proving to be *Trypeta fratria*, as it was then known.

In 1899, Mr. R. W. Doane published a note on this species,[b] recording its rearing from Heracleum from Almota, Wash., and its occurrence at Pullman, Wash. He considered Thomson's *liogaster* the same species, and stated also that our species may be identical with the European *Acidia* (*Trypeta*) *heraclei* L., or celery leaf-miner, said to be a destructive enemy of celery in England.

DESCRIPTION.

The fly.—The mature fly in life is a beautiful object. Its body is pale yellow, as are also the legs; the abdomen is pale green, and the wings are beautifully ornamented with yellow alternating with white, forming the pattern shown in figure 1, *a*. Near the middle of the anterior margin of the wings there is a dusky, nearly black spot,

[a] Insect Life, Vol. VII, p. 383.
[b] Journ. New York Ent. Soc., Vol. VII, p. 178.

while in the corresponding position on the posterior margin there is a paler dusky spot two or three times as large. The head is yellow, and the eyes large and brilliant green with bluish reflections. The ovipositor varies from yellow to black. None of these colors is so bright in preserved specimens. The length of the body is about three-sixteenths of an inch (5 mm.), and the wing expanse is seven-sixteenths of an inch (11 mm.).

The larva, or maggot (fig. 1, *b*).—The larva, or maggot, is of the usual form of the Trypetidæ, measuring about five times as long as wide. It is nearly transparent, except in the interior portions, where it is yellowish. The contents of the abdominal cavity appear greenish through the skin. The length of the body is 7 mm. and the width 1.4 mm. The anal segment of the larva as seen from the extreme end is illustrated at figure 1, *c*.

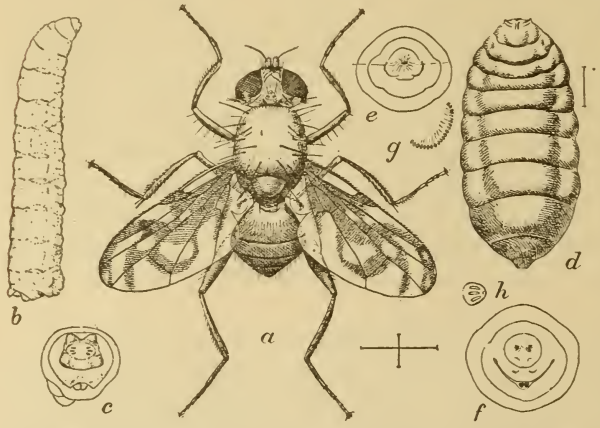

FIG. 1. The parsnip leaf-miner (*Acidia fratria*): *a*, Fly; *b*, larva, lateral view; *c*, anal segments of same; *d*, puparium; *e*, cephalic extremity; *f*, anal extremity; *g*, row of cephalic spiracles; *h*, anal spiracles. *a*, *b*, *d*, Much enlarged, remainder more enlarged. (After Coquillett, except *b*, *c*, original.)

The puparium.—The larva when full grown contracts and hardens, forming a coarctate pupa or puparium (fig. 1, *d*), serving the purpose of a cocoon in inclosing the true pupa. In the present species, as with others of this group which have been studied, the form is oval in outline, imperfectly cylindrical, and tapering almost equally at both ends.[a] The lower surface is somewhat flattened and attached to the leaf by a viscid secretion. The length is twice the width and the color pale green when first formed, changing to straw color with greater age. The body is composed of 11 strongly marked segments. The mouth-parts are retracted within the pupal skin, and the cephalic or thoracic appendages (spiracles or tracheæ) are well indicated, forming two arcs, together equivalent to about two-thirds of a circle (fig. 1, *e*). The spiracles are very minute and difficult to count, but there are evidently between 21 and 24 on each side (fig. 1, *g*), the probabilities being that there is no constancy as regards the number. The length is 4.5 mm. and the width 2.25 mm.

[a] The writer fails to see how the Trypetid pupa can be described as "barrel-shaped," as is done by many writers.

The anal extremity is illustrated at *f*, figure 1, and the anal spiracle at *h*.

As long ago as 1873 Osten Sacken assigned this species to typical Acidia, but it has been generally known as *Trypeta fratria*. The following short technical description is quoted from Osten Sacken:[a]

> Clay-yellow, stature short and somewhat broad, with four bristles on the scutellum; wings with yellowish-brown rivulets, which enclose an oval, hyaline spot before the end of the discal cell; the end of the fourth longitudinal vein is not curved forwards.

DISTRIBUTION.

The localities recorded for *Acidia fratria* are comparatively few, considering the fact that the species is not really rare. Osten Sacken gave "Atlantic States." Thomson found it in California, and others have recorded its occurrence in Missouri, Washington, and New Jersey. To this must be added the District of Columbia. The above evidently indicates a moderately wide distribution, especially if the species should prove to be the same as *heraclei* L., common to both continents. At least it extends across the continent from the Atlantic seaboard to the Pacific Ocean.

BIOLOGIC NOTES.

While new data have been obtained, the life history is still incomplete. The fly has not been observed depositing its eggs, and the egg and method of oviposition therefore remain unknown. The fact that the mines always extend to the margin of the leaf affords an indication that the eggs are deposited at least near the margin, and the fact that the larvæ when full grown have usually worked down into the end of the leaf nearest the leaf-stalk (see fig. 2, *a*) shows that the egg is probably deposited in most cases near the other end or apex of the leaf.

The larvæ under observation in 1903 began to attain maturity July 19, the adults issuing in August. Material under observation in 1908 transformed to pupæ May 22 and the first adults issued June 6, the pupal period having been passed in fourteen days.

While these insects usually form puparia in the old larval mines, in many cases also they desert the mines, especially small ones, and form separate puparia in the same or other leaves. Mines are more often found with two or three larvæ or puparia within than with a single inhabitant, and as many as eight have been counted on a single leaf. To the average person the mines made by this species would scarcely be recognized as such, as the leaves merely present the appearance of dying from natural causes, portions of them drying and withering.

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[a] Monograph of Diptera No. Am., Pt. III, p. 234.

At the time when puparia are formed on the leaf surface (see fig. 2, *b*) that portion of the leaf is still green, but before the adult hatches the infested area usually turns brown, like the larval mines, and the first two or three segments of the puparium may be seen protruding at the margin of the leaf. With the further drying of the leaves more segments are exposed, and sometimes the entire puparium is brought to view (fig. 2, *c*) attached by its underside to the surface of the leaf.

FIG. 2.—Parsnip leaves showing location of larva of *Acidia fratria* in its mine at *a;* of concealed puparia at *b*, and of exposed puparium at *c* Drawn from life. (Original.)

The mines are of irregular form, but are usually more or less rounded or oblong, although sometimes irregulary triangular when found in the apex of a leaf. The two outer surfaces of the leaves become separated, and the excrement, very fine and powdery and nearly black, can be seen by holding the mines to the light. The location of the larvæ can also be made out in the same manner if, indeed, the larvæ can not be seen on a plain surface.

The maggots usually work somewhat closely together, and the puparia also are frequently found placed side by side. Lower leaves of plants are more affected than are upper ones, and attack has been noticed to be more extensive where plants are grown in shady locations.

A single parasite, *Syntomosphyrum* sp., a chalcidid, determined by Mr. J. C. Crawford, has been reared by the writer from this maggot.

METHODS OF CONTROL.

According to the writer's experience, this species shows a fondness for plants that have run to seed. Hence it is not desirable to plant beds in the vicinity of parsnip or other susceptible crops grown

for the market. European writers on the celery leaf-miner state that dusting the affected leaves with a mixture of finely powdered soot and lime, three parts to one, has proved beneficial in preventing the flies from depositing their eggs upon the leaves. It is applied when the leafage is damp. Other similar deterrents, such as road dust, would have about the same effect.

Sprays of kerosene emulsion and of carbolized kerosene emulsion have also been reported to be successful in the treatment of young plants affected by the celery leaf-miner. These, if applied at the proper time, would act as deterrents and might have some effect on the larvæ at about the time when they are ready to transform to pupæ and when the mines are thin. It is doubtful, however, if either of these fluids would penetrate the leaves to any great extent except at this time.

THE PARSLEY STALK WEEVIL.

(*Listronotus latiusculus* Boh.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

INJURIOUS OCCURRENCE.

Certain species of curculios, or weevils, of semiaquatic habits that normally feed upon wild plants growing in marshy situations, through the reclamation and cultivation of such tracts, occasionally attack crop plants, and for a season or more accomplish serious damage. In many instances injuries are peculiarly local and are not apt to recur,[a] but there is always a possibility that insects of such habits may, in course of time, after the cultivation of the same areas, with or without the disappearance of these wild food plants, become permanent pests. An instance may be cited which came under the observation of Prof. F. M. Webster, of this Bureau, in Ohio, in 1894, of attack on cabbage by two semiaquatic species of weevil, *Listronotus appendiculatus* Boh., and *Notaris* (*Erycus*) *puncticollis* Lec. About 50,000 plants were set late in June in a field of swamp land underdrained the previous year, and as many as 10 individuals of the first-mentioned species were found about single plants, gouging great cavities in the stalks. The former, with others of its genus, develops normally in arrow-head (*Sagittaria* spp.) and some related aquatic plants.

It is not surprising, then, that similar injuries should be committed by insects of the same class. During the last of July and first days of August, 1902, Mr. F. C. Pratt, of this Bureau, noted injury to parsley grown at Four Mile Run, Virginia, which upon examination was found to be due to both larvæ and adults of *Listronotus latiusculus* Boh. Injury continued the following season—1903. It thus extended over four years—1900 to 1903, inclusive.

[a] This holds for several forms of bill-bugs (*Sphenophorus* spp.), but the most injurious species are practically permanent corn pests in certain localities, owing to environment; for example, in cornfields planted in the immediate vicinity of marshes, rivers, or other bodies of water in which the aquatic plants in which they have their natural homes abound.

DESCRIPTION.

The beetle is a weevil of the family Curculionidæ. It is of somewhat obscure appearance, there being many other species which resemble it superficially. It is shown in the illustration (fig. 3, *a*). Its resemblance to the clover-leaf weevil and related species (Phytonomus) is apparent. The two genera are intimately related. From the latter genus Listronotus may be distinguished by the different proportions of the ventral segments, the first, second, and fifth being long, and the third and fourth very short. The legs are more slender, and the tibiæ are bent inward at the tips and are quite strongly mucronate. The species, so far as known, are winged. Twenty-two species are indicated by Horn.[a] *L. latiusculus* Boh. is very closely related to *L. impressifrons* Lec. Le Conte describes the two species as agreeing in form and sculpture and in having the last ventral segment of the female not impressed, but in *latiusculus* the rostrum or snout is feebly channeled and sulcate with the frontal fovea faintly indicated, while in *impressifrons* the rostrum is strongly channeled and sulcate with the frontal fovea deep. The length without the rostrum is about one-fourth of an inch (6–7.5 mm.). The color is brown, varied with rather minute golden or cupreous scales, with which the entire surface is covered. The rostrum from the eyes to the tip is of nearly the same length as the thorax.

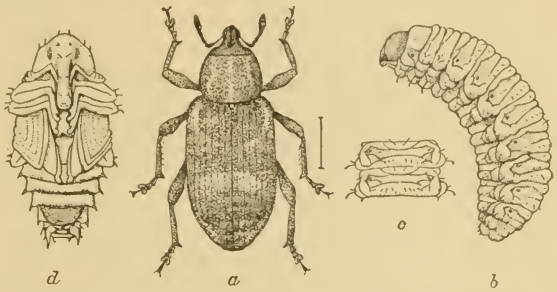

FIG. 3.—*Listronotus latiusculus: a*, Beetle; *b*, larva from side; *c*, two abdominal segments from above; *d*, pupa. All much enlarged. (Original.)

The egg.—The egg is variably oval, from about two-thirds to three-fourths as wide as long, not visibly flattened, and without apparent sculpture. The only eggs examined were of a decidedly dusky hue, but when freshly laid they were probably pale gray or whitish and subtranslucent. Their length is 0.70–0.75 mm., and the width 0.48–0.55 mm.

The larva (fig. 3, *b*, *c*).—The larva differs from those of the ordinary Curculionid form in being less curved. It is considerably flattened and crawls easily, being comparatively active. The larva in the cut is shown in the position assumed after death. When alive and stretched at full length it is a trifle longer than the beetle. It is of the usual milk-white color so common in curculio larvæ, and has the same pale, reddish-brown head and darker mouth-parts. The

[a] Rhynchophora of America North of Mexico, 1876, pp. 127–136.

head is comparatively small, of about the same width as length, excluding the mouth-parts.

The pupa (fig. 3, *d*).—The pupa is creamy white in color and is rather thickly covered with short, stiff bristles, which assist it in locomotion. It is quite active and capable of crawling a considerable distance.

DISTRIBUTION.

Le Conte's type and cotypes were from Georgia and Louisiana. The species is recorded or has come under the writer's notice from a limited number of localities. These include Ithaca, N. Y. (Chittenden); New York, N. Y. (Juelich and Roberts); Buffalo, N. Y. (Juelich); Madison, Gloucester, and Hudson County, N. J. (Smith); Four Mile Run, Va. (Pratt); and Washington, D. C.

INJURY AT FOUR MILE RUN, VIRGINIA.

When this species was first observed, in the latter part of July, several larvæ and a single adult were found in the tuberous roots underground. The trucker on whose farm the injury was committed stated that he had observed attack by this species the two years before, i. e., in 1900 and 1901, when it occasioned some loss. The outward manifestations consist in the tops of the parsley beginning to turn yellow, then wilting, and finally drying out. When a plant was pulled, the roots broke off just below the surface of the ground, frequently dislodging the larva or grub and leaving others below. September 5, when a third visit was paid to the infested locality, injury had increased beyond all expectations, nearly half of the crop having been destroyed. As in the previous instance, larvæ and adults were found, as also pupæ. It is obvious, therefore, that the single adult found on the first occasion was a straggler from the first or hibernated generation and the beetles found later were members of the new generation. Where the larvæ were found attacking small stems—those less than a quarter of an inch in diameter—injury was shown quite early and the plant was killed. But in older stems from one-half to three-fourths of an inch in diameter damage was not so conspicuous. Large tubers show excavations on an average of about 1 inch in length and a fourth of an inch in diameter. Owing to the soft nature of the roots these excavations are decidedly irregular and assume a light reddish-brown color. The holes made by the beetles in exit are so large that sometimes considerable quantities of earth are washed in by rains and doubtless assist in promoting decay, leading to the ultimate destruction of the plants. Some of the outer roots proceeding from the tubers are also penetrated. In one root under examination, containing two larvæ, less than one-fourth of the root remains, the rest having been destroyed by decay. In 1903 larvæ were observed as

late as September 4, hatching in the outside leaf-stems and burrowing through until they had penetrated the root. In the illustration (fig. 4) injured plants are shown, the one on the right containing a larva, natural size, in the roots.

OVIPOSITION.

It was readily learned that the beetles deposited their eggs in parsley stalks, large punctured areas corresponding to the diameter of the snout of the beetle being noticeable from a point just below the top

FIG. 4.—Parsley roots showing work of parsley stalk weevil. (Original.)

of the stalks nearly to their base. Three or four such places of egg deposit are usually seen in a large stalk. The usual number of eggs inserted seems to be two, although frequently a third is found and sometimes only one. Most curculionids, however, deposit a single egg in a slit made for the purpose. Where the stalk has attained sufficient size and strength to continue growth after the beetle has deposited its eggs, the larva lives within it, going downward into the roots. In some cases plants are killed by too many punctures, particularly when quite small and delicate, and then the larvæ desert the

stems, evidently by simply tumbling out to the ground, into which they crawl and attack the roots by boring in from outside.

FOOD PLANTS AND HABITS.

Most collectors of Coleoptera who have had opportunity to observe aquatic and other forms of beetles that frequent ponds and water courses are familiar with the fact that the genus Listronotus is to be found in the greatest abundance on aquatic or semiaquatic plants, more particularly on Sagittaria. Years ago Dr. C. M. Weed made observations on the present curculio and its food habits.[a] He found the larvæ in seed capsules or heads, as well as in stalks, of the common arrow-head (*Sagittaria variabilis*) and furnished some interesting observations on the insect's life history. Beetles began to emerge September 23 (in Ohio), continuing emergence until the middle of October. The length of the pupal stage was determined as eleven days. The duration of the egg stage should be about the same at the same temperature, but in a high temperature in a warmer climate like that of Washington eggs might develop in seven days, while the larval stage is of only a few weeks' duration. During the same year that Doctor Weed wrote of this species, the late Wilhelm Juelich informed me that he had found the beetles near New York City in the lower parts of reeds (Phragmites), near the bottoms.

In the Bureau of Entomology we have a record of the finding of the larva by Mr. A. Koebele in August, 1884, in Virginia, near the District of Columbia, in the seed capsules of a species of Sagittaria, August 31. The beetles developed in great numbers, beginning September 22.

It is not usual that phytophagous Coleoptera develop in so many portions of a plant as in the case of the present species, which exists as larva in the seed capsules and stalks of one plant and in the roots of a different plant.[b] It is not probable that it would be able to live in portions of purely terrestrial plants other than the roots or stalks near the ground, because the insect evidently requires a more than usual degree of moisture. In other words, it is semiaquatic.[b]

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[a] Bul. Ohio Agr. Exp. Sta., Tech. Ser., Vol. I, No. 1, pp. 10, 11, 1889.

[b] Compare the writer's observations with others on the biology of *Conotrachelus elegans* (Bul. 18, n. s., p. 94), which breeds commonly at the roots of Amaranthus and has been stated by others to live on hickory; since the eggs are known to be deposited in rolled-up leaves of hickory, it seems probable that the beetles develop in some other portion of that plant than at the roots. The congeneric plum curculio (*C. nenuphar* Hbst.) not only develops in the plum and other stone fruits, but also in black-knot (*Plowrightia morbosa*).

METHODS OF CONTROL.

The grower who reported injury to parsley in Virginia abandoned this crop on account of the ravages of the weevil. Hence no experiments could be made with remedies. There can be no doubt that the species could be reached with bisulphid of carbon or kerosene emulsion applied about the roots in the same manner as for root-maggots and similar insects. All things considered, however, in the case of parsley the wisest measure was just what the grower did. After the lapse of a year or two, perhaps, parsley might be grown with impunity in the same locality.

THE CELERY CATERPILLAR.

(*Papilio polyxenes* Fab.)

By F. H. Chittenden, Sc. D.
In Charge of Truck Crop and Stored Product Insect Investigations.

INTRODUCTION.

Everywhere in beds of celery, carrots, parsley, and related plants there will be found, during summer and autumn, numbers of a large green or yellowish caterpillar, ringed with black. This is the celery caterpillar, known also as the parsley worm and by other common names. It is, everything considered, one of the insects best known to the grower of the crop plants mentioned, this being due to its large size and conspicuous, gay coloring. It feeds upon the leaves of plants and, when abundant, attacks the blossoms and undeveloped seeds. If left entirely unmolested it might, save for the intervention of natural enemies, become a serious pest, since it is a voracious feeder. It is readily controlled, however, by handpicking, and this helps to reduce the numbers of the pest. In addition, its habit of feeding on wild parsnip, wild carrot, and other umbelliferous weeds, which are altogether too abundant, serves to distribute attack as well as to divert it from useful plants.

DESCRIPTIVE.

Nearly every year inquiries are made in regard to this insect, but it is seldom so plentiful as to call for advice in regard to treatment. Complaints of injury and requests for remedies, however, have been received in recent years from portions of Long Island, Maryland, District of Columbia, Virginia, Iowa, and some other regions. In our correspondence it has attracted most attention because of its occurrence on celery, parsley, and sweet fennel.

The egg.—The egg of this butterfly is of globular form and rather large, measuring about 1 mm. in width and the same in height. It is flattened on the surface by which it is attached, as shown in figure 5, *d*. When first laid the egg is pale honey-yellow, but afterwards turns in parts to reddish brown. The surface is slightly glistening and covered with microscopic granulations.

The larva.—The young stages of the larva are totally dissimilar to the mature ones. Five distinct stages are recognized, the second of which is illustrated at *e*, figure 5. This caterpillar is shown, lateral view, in figure 5, *a*. It is usually green, sometimes yellowish, and strongly ringed with velvety black and spotted as figured. Another caterpillar is shown at *b* to illustrate the appearance of the head and the peculiar yellow scent organs (osmateria). These are protruded when the insect is disturbed, and they exhale a pungent odor, similar to that of the bruised leaves of their food plants but of greater intensity and very disagreeable.

The adult.—The parent insect is one of the swallowtail butterflies known by various names, but more commonly as the black swallowtail. The ground color is velvety black, relieved by yellow bands in

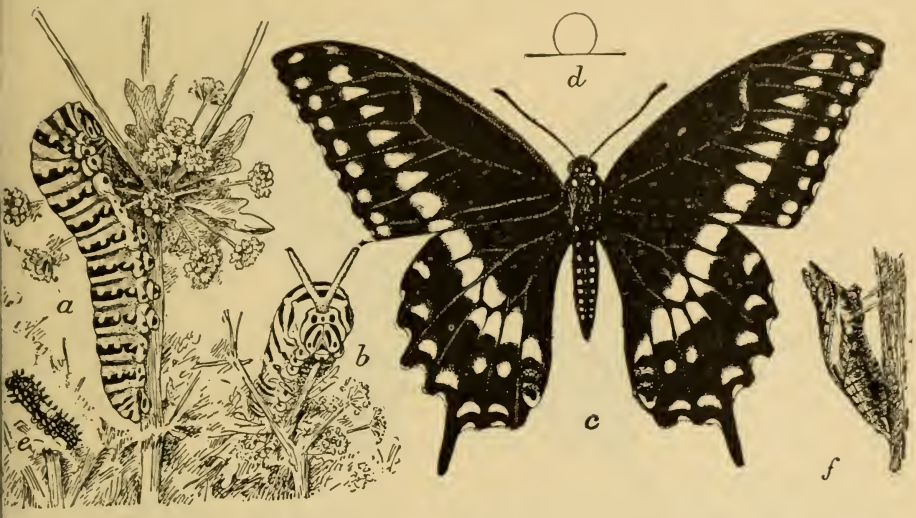

FIG. 5.—The celery caterpillar (*Papilio polyxenes*): *a*, Full-grown larva, side view; *b*, view showing head with extruded osmateria; *c*, male butterfly; *d*, egg in profile; *e*, young larva; *f*, suspended chrysalis. All about natural size, except *d*, which is much enlarged. (Original.)

the male, as shown in the illustration (fig. 5). The hind wings are ornamented on the inside by eyelike markings resembling those of the male peacock, and they terminate in the "tails," from which the insect derives its common name. The female (fig. 6) is of larger size, somewhat faded black, and in every way of a more somber appearance than her spouse—a rule which holds good for most butterflies. Many of the yellow spots, particularly those arranged in the form of bands, are wanting, and the hind wings are ornamented with pale blue scales on the posterior half. This species is subject to every conceivable variation in color. The wing expanse is usually 3 inches or a little more.

The chrysalis.—The chrysalis is of a dull gray color, mottled with black and brown, and measures a little less than 1¼ inches (see fig. 5, *f*).

DISTRIBUTION.

In some respects this is one of the most interesting of the insects found attacking garden plants. In the first place, it appears to be limited to no special life zone, if we can judge by the records of distribution. It occurs in every State and Territory in the Union. From a very considerable portion of Canada from east to west bordering the United States, its range extends through Central America and the West Indies to South America, at least as far as Venezuela.

HABITS AND LIFE HISTORY.

Even without the warning scent organs with which the larva is supplied, its colors are so peculiar that birds soon recognize it and learn to leave it undisturbed, owing to its disagreeable taste. It is not, however, free from insect enemies. It would seem that the

FIG. 6.—The celery caterpillar: Female butterfly. About natural size. (Original.)

larva is perfectly well aware of its immunity from attack by birds, since it feeds in plain view in the later stages and even crawls to the outer surface of plants, appearing to invite the freest exposure. It is remarkable, also, that the colors of the pupa as well as its attachment to inconspicuous objects render it comparatively free from natural enemies. Fitch (in manuscript) noticed "a female at midday hovering around some caraway, ovipositing. She gently settles on the end of a leaf, holding thereto with her feet for a few moments, whilst she curves her abdomen forward and places an egg on the upper surface of one of the small leaflets, and then gently flies away to another leaf."

Owing to the extremely wide range of this species there is much variation in its life history. Gundlach and Chapman observed this insect in Cuba and Florida, respectively, and their observations, with those of others farther north, show that the eggs hatch in from

four to nine days, that the larval period may be passed in the extreme South in from nine to ten days, although this is oftener four weeks in the North, and that the chrysalis period varies between nine and eighteen days. The writer observed the pupal period at Washington, D. C., from July 8 to July 18, a total of nine and one-half days in hot weather. This gives us a possible minimum life cycle of from twenty-two days, in the insect's southern range, to eight weeks northward. In the North the insect is double-brooded, and winters in the chrysalis stage. In the extreme South there are probably three or four generations produced each year. Thus butterflies appear in the South in March and April and begin the deposition of their eggs, while in the New England States and in similar latitudes the butterfly does not appear on the wing until May, and seldom before the middle of that month.

Besides celery, this insect attacks practically all other umbelliferous plants, including carrot, parsley, caraway, fennel, parsnip, dill, and related wild plants. It does not appear to attack, except in extreme cases, any plant outside of this botanical family.

NATURAL ENEMIES.

The principal insect enemies are species of ichneumon flies of rather large size, single specimens of which serve to destroy the insect in its pupal stage. The best known of these are two species of Trogus—*exesorius* Brullé and *exidianator* Brullé. Some other natural enemies, however, have been recorded. The list includes *Apanteles lunatus* Pack. and a dragon fly, *Anax longipes* Hagen.

REMEDIES.

The conspicuous appearance of the larvæ of this species renders them what might be called an "easy mark," as they are readily found and can be crushed under foot, and no other remedies are necessary if the work of destruction is begun before the plants are injured. The killing off of the first generation will serve in considerable measure to destroy the insects so as to prevent a very large second brood or generation, particularly if this can be accomplished over a considerable territory. The butterfly is a strong flier, and cooperation is necessary to keep the insect in check when it becomes destructive. The caterpillar can also be destroyed with an arsenical, either Paris green or arsenate of lead, but recourse to these is, as a rule, scarcely necessary, owing to the ease with which the "worms" can be hand-picked.

BIBLIOGRAPHY.

The swallowtail butterfly is considered in most text-books on general entomology and in many popular periodicals on the same topic. A list of technical references is given in Scudder's Butterflies

of New England—mentioned as No. 6 below—and a list of publications in which the immature stages are considered is furnished in Henry Edwards's Catalogue of the Described Transformations of the North American Lepidoptera (No. 5). A brief list is, therefore, all that is necessary for the present purpose.

(1) Fabricius, J. C.—Systema Entomologica, pp. 444–445, 1775.
Original description of the species as *Papilio polyxenes*.

(2) Smith & Abbot.—Lepidopterous insects of Georgia, vol. I, p. 1, pl. 1, 1792.
Short account, with colored plate, illustrating all stages except egg. Mentioned as *Papilio troilus*.[a]

(3) Cramer, Pieter.—Papillons exotiques, Vol. IV, pp. 194–196, pl. 385, figs. C–B, 1782.
Redescribed as *Papilio asterius*.

(4) Harris, T. W.—Insects injurious to vegetation, 1841, pp. 211–213, Flint ed., 1862, pp. 263–266, pl. 4, fig. 4.
An excellent account of this species with illustrations. Mentioned as *Papilio asterius* Cram.

(5) Edwards, Hy.—Bul. 35, U. S. National Museum, p. 10, 1889.
List of references to the described transformations of this species to date.

(6) Scudder, S. H.—Butterflies of the Eastern United States and Canada, Vol. II, pp. 1353–1364, 1889.
A monographic account, including references to technical descriptions of all stages, geographical distribution, habits, life history, etc.

[a] *Papilio troilus* L. is an entirely different species.

U. S. D. A., B. E. Bul. 82, Part III. Issued December 28, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE LIMA-BEAN POD-BORER.

(*Etiella zinckenella* Treit.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

INJURIOUS OCCURRENCE.

In looking over some old material and notes in the Bureau of Entomology and National Museum, some larvæ closely resembling the Lima-bean vine-borer (*Monoptilota nubilella* Hulst) were discovered, accompanied by a note by Mr. Albert Koebele to the effect that they were found on Lima beans at Rattlesnake Bridge, Eldorado County, Cal., July 21, 1885. The beans in that vicinity were much infested by larvæ of this species. The seed beans had been received from Ohio the previous spring, but this evidently had no bearing on the origin of the insect, although the larvæ injured the growing seeds.

More recently, in 1908, the same species was discovered by Mr. H. O. Marsh at Santa Ana and Garden Grove, Cal., in September and October, infesting Lima-bean pods. At this time it was abundant in Santa Ana, in one garden nearly every pod containing a larva; at Garden Grove the species had ruined fully 40 per cent of a good-sized patch of late beans. Another lot was received from Anaheim, Cal., October 22. The larvæ were common at this time also but not as injurious as in the other localities. The adults began issuing January 9, 1909, and continued coming out until February 25.

Later the same collector found this species at work at Compton and Watts, Cal., in November. During the latter half of November the larvæ were scarce, practically all having disappeared with the exception of a few belated individuals here and there.

DESCRIPTION AND DISTRIBUTION.

The moth has a wing expanse of a little less than an inch; the head is armed with three long, conspicuous labial palpi, showing its relation to the snout-moths. The ground color is gray, interspersed

with ochreous scales on the fore wings. A conspicuous, broad white stripe extends over the base of the fore wing along the costa to the apex. In the inner fourth of the fore wing there is also a cross-band of brighter ochreous freely dotted with brown spots. The moth is illustrated by figure 7, *a*, representing the female. The sexes may be readily distinguished by the antennæ.

The original description of this species is by Treitschke,[a] who, in 1832, named it *Phycis zinckenella* n. sp., from Sicily.

It has also been described under at least thirteen other names, including *schisticolor* Zell., and *rubribasella* Hulst. Full references to technical descriptions are given by Hulst in his article entitled "The Phycitidæ of North America"[b] and in the Dyar list (No. 4807).

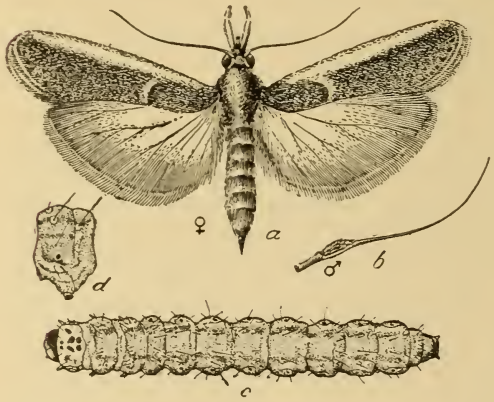

FIG. 7.—Lima-bean pod-borer (*Etiella zinckenella*): *a*, Female moth; *b*, antenna of male moth; *c*, larva, dorsal view; *d*, lateral view of one abdominal segment. Twice natural size except *b*, which is more enlarged. (Original.)

Doctor Dyar has suggested that *schisticolor* Zell. is synonymous with *zinckenella* Treit. and in further elaboration states, in a letter dated May 28, 1909:

> I have compared the Etiella species and find only one and that the same as the European *zinckenella*. Hulst's *rubribasella* is evidently a synonym, founded on an imperfect or badly mounted specimen: *schisticolor* Zell. is paler gray, less reddish tinted, the costal stripe less sharply defined, but I think it a racial form only. Many of our moths that extend into the arid country are of a paler gray there, to match the desert tints; but I do not think the character is specific. The costal stripe in some of the specimens is as sharply marked as in eastern ones, and the eastern ones also vary in depth of color.

Like the pea moth, this species appears to be an inhabitant of the Eastern Hemisphere and has been introduced, perhaps, from both Europe and Asia. North Carolina is the northernmost locality recorded by Hulst, but it may be present farther north in the Atlantic region.

Of its habits Milliére[c] says that it lives in the larval stage on *Colutea arborescens*.

Of the distribution Hulst gives Florida, North Carolina, South Carolina, Texas, Colorado, California, West Indies, South America,

[a] F. TREITSCHKE. Schmetterlinge von Europa, Vol. IX, p. 201, Leipzig, 1832.
[b] Trans. Am. Ent. Soc., Vol. XVII, p. 170, 1890.
[c] Ann. Soc. Linn. Lyon, Vol. VIII, p. 231, 1861? Not seen.

Europe, West Africa, Madagascar, and Central Asia. Evidently the species is cosmopolitan but may not occur far northward.

Comparison of the moth of this insect with that of the corn stalk-borer (Elasmopalpus) shows considerable superficial resemblance, while the larva is decidedly more like that of the Lima-bean vine-borer (Monoptilota). In the Dyar list the genus Etiella follows three genera after Elasmopalpus. These three species belong to the same family, the Phycitidæ.

The larva.—The larva, when mature, presents the appearance illustrated in figure 7, *c*, *d*. It is of robust form, strongly convex above, and somewhat strongly flattened on the lower surface; widest at the first two abdominal segments, from which it tapers very feebly both anteriorly and posteriorly until the anal extremity, which is much narrowed. The general color is rosy, sometimes with a purplish tinge, much darker on the dorsal than on the ventral surface, which is somewhat faintly tinted. Segmentation is strong and the abdominal folds are pronounced. The head is more than half as wide as the first thoracic segment, honey-yellow in color, darker about the trophi and along the margins; the hemispheres are well divided above; the inverted V-mark is distinct, the outer lines broken above the middle. The first thoracic segment is paler than the other two, tinged with honey-yellow, and spotted with brown, about as illustrated in figure 7, which also shows the pattern of ornamentation of the dorsal surface generally. The anterior legs are well developed as are also the four pairs of abdominal and the anal prolegs. The arrangement and location of the piliferous tubercles and hairs which they bear are also sufficiently well shown to render further description superfluous, especially as only a single properly preserved specimen is available for the purpose. The length is about 16 mm.

Younger larvæ seen were pale, either whitish or light green.

The eggs have not been seen and no pupæ are at hand for description.

ADDITIONAL REMARKS.

Opportunity has thus far not offered for study of the habits of the species. Of the larvæ received, it was noticed that they feed entirely within the pod and in some cases were found in a slight web mingled with excrement. They attack the bean along the edge and usually devour the germ, consuming the entire bean if young and tender. They are quite capable of entering other pods by cutting a small hole in the side.

Larvæ were seen crawling around in a package when received, September 23, evidently seeking a place for pupation. When placed in

a rearing jar with sand they burrowed down to the depth of an inch or a little more and surrounded themselves with a slight web.

It is noticeable that this species was found only upon Lima beans in its occurrence in California.

An ichneumon-fly parasite (Chttn. No.1412°) issued October 19 to October 30, 1908.

As a very complete systematic bibliography is published by Doctor Dyar,[a] and, moreover, as the titles cited have little bearing on the matter in point, bibliographical references will be omitted in the present paper. Admitting that *zinckenella* and *schisticolor* are synonyms, the Dyar catalogue furnishes no less than fourteen synonyms, the species having been given that number of specific names by different writers, the list including six by Walker.

No opportunity has presented itself for experiments in the remedial control of the insect, and unless it should be held in check by natural enemies it is probably destined to be a pest during some seasons, in localities where it has become well established, on Lima beans.

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[a] Bul. 52, United States National Museum, p. 428, 1902.

THE YELLOW-NECKED FLEA-BEETLE.

(*Disonycha mellicollis* Say.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

[With report by H. O. Marsh, *Agent and Expert.*]

INJURIOUS OCCURRENCE.

Beginning with January, 1909, the yellow-necked flea-beetle (*Disonycha mellicollis* Say), which appears to be particularly injurious the present year, began to attract attention in the South, being reported, by agents and others, on truck crops in Texas and Florida. January 26, Mr. D. K. McMillan stated that this species was common at Brownsville, Tex., on spinach. He found only adults, although several pairs were in copula. He had also found adults resting under portulaca and amaranthus and on lettuce. At that time it had not proved very injurious, but was so much more abundant than in the previous year that it was surmised that the insect might become a pest. The following day we received the same species on beets, collected by Mr. H. M. Russell, at Boynton, Dade County, Fla. In this case both adults and eggs were obtained. The latter were deposited in masses of six, ten, and eleven on the underside of the leaves. January 29 Mr. Roger S. Baldwin, Boynton, Fla., wrote that beets were being attacked by the spinach flea-beetle. The specimens sent in each case proved to be *Disonycha mellicollis* Say and not *Disonycha xanthomelæna* Dalm.

Writing about the yellow-necked flea-beetle, February 12, Mr. Baldwin stated that the adults were taken from table beets grown at Boynton, Fla., on black, wet, mucky soil. He expressed the opinion that these might represent a second generation, as all that were seen on the earlier beets were handpicked or treated with arsenate of lead in the form of a spray. The earlier beets were then entirely freed from the insects' attack. Later, on March 6, Mr. McMillan found adults in considerable numbers on spinach and beets, the leaves of which showed holes made by the insects in feeding. No larvæ were observed at that time, but the adults were mating and a few eggs were found.

In looking over earlier records the writer finds that in the summer of 1897 he first noticed this flea-beetle in numbers taking short jumps about the common purslane, *Portulaca oleracea*, at Glen Echo, Md.

Individuals that were kept in a vial with the leaves of this plant fed freely for two weeks, whereupon one deposited eggs. A mass of 23 eggs was obtained, laid irregularly, some in rows of three or four with similar rows overlapping. When first noticed, the eggs were about to hatch and were blood-red—an unusual color for the eggs of Chrysomelidæ. They differ from those of the closely related *D. xanthomelæna*, or spinach flea-beetle, chiefly by their sanguineous color, but agree, as far as could be easily seen, in all other important particulars.

The larvæ, as well as the adults, feed on portulaca. Apparently the larva does not differ to any noticeable extent from that of *xanthomelæna* save in color and in possessing less prominent tubercles. The general color is rather dull yellowish-red with no apparent striation. The size is also a little smaller.

September 20, 1906, Mr. F. W. Roeding sent beetles of this species from Wichita Falls, Tex., with the report that they occurred in beet fields.

No further observations were made on this species until November 5, 1907, when the writer observed it on chickweed (*Alsine* [*Stellaria*] *media*), one of the favorite food plants of *xanthomelæna*. Several other beetles were observed in the same location and these fed upon chickweed when provided with it. In April, 1909, this species was taken under boards placed over chickweed and when confined fed more freely than did the lot found in November, presumably because the latter had begun hibernation. The following year, May 30, Mr. McMillan observed the beetles feeding on portulaca at Brownsville, Tex., showing, in the writer's opinion, and as he had previously surmised, that this is a favorite natural food plant.

DESCRIPTION AND DISTRIBUTION.

This species was given the specific name which it now bears by Say, in 1835.[a] Later it was redescribed by Le Conte as *semicarbonata*.[b] Of the eighteen species of this genus, *mellicollis* differs from all others, except *collata* Fab., in having entirely yellow femora or thighs. It is smaller than either *xanthomelæna* or *collata*. The color varies. In fresh specimens the legs and thorax are reddish, but in older specimens they are much paler and the thorax varies from metallic green to dark blue. The species was redescribed by Horn in 1889.[c]

This species is as widely distributed as the average Halticine, but it was not until rather recent years generally recognized by collectors as distinct from *xanthomelæna*. It is recorded by Dr. G. H. Horn

[a] *Altica mellicollis*, Bost. Journ. Nat. Hist., p. 199; Complete Writings (LeConte Ed.), Vol. II, p. 668, 1859.

[b] *Haltica semicarbonata*, Col. Kans. & E. New Mex., p. 25, 1859.

[c] Trans. Am. Ent. Soc., Vol. XVI, pp. 211–212, 1889.

from Louisiana, Texas, and Colorado. The writer has collected specimens from New York City and vicinity, the District of Columbia, Rosslyn, Va., and Glen Echo, Md., and has seen a series from North Carolina. In the streets of New York he observed beetles under stones as early in the season as March 13.

It has been recorded from as far inland as Cincinnati, Ohio, but it is apparently a maritime form, as it is not often found inland. It should be remarked that it is, like other flea-beetles, decidedly spasmodic as regards numbers.

ECONOMIC STATUS.

The economic status of this species is scarcely established. It is not at all unlikely that it may prove in time to be quite as injurious to beets and spinach, locally or seasonally in the Gulf States, as is its injurious congener, the spinach flea-beetle, throughout the North and in the Atlantic region. The latter, there can be no doubt, does much more injury annually than is attributed to it, for reasons which the writer has already expressed. When it attacks very small plants, especially in the larval stage, it may destroy them completely and then attack the roots.

The following report on this species gives some details not covered by the preceding pages:

REPORT BY H. O. MARSH.

The beetles of *Disonycha mellicollis* were observed during the winter and spring of 1909 to be quite common and injurious at Brownsville, Tex., and vicinity, feeding on beets, spinach, *Amaranthus retroflexus*, *A. spinosus*, *A. berlandieri*, *Chenopodium* sp., *Portulaca retusa*, and *P. oleracea*. Injuries, from an economic standpoint, were confined to beets and spinach.

January 26, the beetles were common on spinach and a few specimens were feeding on lettuce. The lettuce was in a row adjoining the infested spinach and it is more than probable that the beetles do not feed on this plant except in rare cases.

Following a "norther" in January a number of beetles were found under dry cow "chips" where they had gone for protection. Several females had deposited their eggs under these; doubtless because they were unable to retain them until reaching a more suitable place. In most cases these eggs were a considerable distance from any food and the larvæ, on hatching, must certainly have starved. During this month eggs were found in the soil at the base of amaranth plants, placed in clusters quite close to the surface.

March 6, the beetles occurred in considerable numbers on spinach and beets, the leaves of which they had badly riddled; a few were present also on lettuce. Many were mating and eggs were found. No larvæ were observed. Females confined March 6 deposited a large number of eggs on March 7, which hatched on the 17th.

During April the beetles were fairly common and were scattered on several food plants. Purslane seemed to be the favorite wild plant. April 2, nearly mature larvæ were observed in some numbers on the underside of spinach leaves.

May 10 the adults occurred in moderate numbers and were feeding in company with *Disonycha abbreviata* Melsh. on the tender foliage of *Amaranthus retroflexus* and

A. spinosus. A cluster of eggs was found in the loose soil at the base of a plant of *Amaranthus spinosus.* From a female confined at this date the following record was obtained:

May 12, eggs deposited to the number of 49.
May 16, eggs hatched.
May 25, larvæ burrowed into soil.
May 27, first larvæ pupated.
June 1, first adults developed.
June 2, adults left cells.

The periods were as follows: Egg stage, 4 days; larval stages, 11 days; pupal stage, 5 days, or a total of 20 days from the time the eggs were deposited until the adults developed.

The female which was confined May 10 deposited another cluster of 40 eggs on May 14 and died May 20.

METHODS OF CONTROL.

The remedies to be observed for this species naturally are practically the same as for the related spinach flea-beetle. These consist in applications of the arsenicals, either arsenate of lead or Paris green, in accordance with the instructions given in Circular No. 87 on the Colorado potato beetle. In addition to spraying it is advisable to keep down the natural food plants of the species, especially purslane and chickweed, and to spray these also, as well as the beets and spinach, when the latter are affected.

U. S. D. A., B. E. Bul. 82, Part IV. Issued May 20, 1910.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE LIFE HISTORY AND CONTROL OF THE HOP FLEA-BEETLE.[a]

(*Psylliodes punctulata* Melsh.)

By WILLIAM B. PARKER,
Collaborator.

INTRODUCTION.

The most injurious insect attacking the hop vines in British Columbia is the hop flea-beetle (*Psylliodes punctulata* Melsh.), which is widely distributed over the northern part of the United States and extends into the southern part of Canada. Although this beetle feeds freely upon rhubarb, sugar beets, and certain truck plants, it was not known as a notably serious pest until a few years ago, when it began its depredations in the hopyards of the Chilliwack and the Agassiz valleys in British Columbia.

ECONOMIC IMPORTANCE.

According to Mr. H. Hulbert, Sardis, British Columbia, the hop flea-beetle was present in the Chilliwack Valley when he began to grow hops there in 1894. However, it made no perceptible increase

[a] This investigation against the hop flea-beetle was made possible through the good offices of the E. Clemens Horst Hop Company, and particularly their general manager, Mr. Theo. Eder. This company is the largest grower in the section concerned, and fully appreciated the necessity of inaugurating studies looking to the control of the insect. At the request of this company Prof. H. J. Quayle, of the California experiment station, spent some time in the infested section in the summer of 1908, during which time the earlier stages of the insect were first made known. The writer began work under his direction the 1st of January, 1909, and continued the work on the problem until the following fall, when Mr. Quayle again took the field, closing up the studies at the time of the harvesting of the hops.

NOTE.—This publication is, in large part, supplementary to an article entitled "The Hop Flea-Beetle," issued in May, 1909, as Bulletin No. 66, Part VI. It is necessarily of a more practical nature, and it is hoped that it will be of great value to the hop growers of the West, and that it will also have some value to the growers of sugar beets and various vegetables, including especially root crops grown in the same region.—*F. H. Chittenden.*

and did very little damage to the hop vines until 1903. During that spring the beetles appeared in large numbers and held the vines back for some time, but by the persistent use of tarred boards they were kept in check and the crop saved. During the seasons of 1904–1908 the beetles gradually increased in numbers, reaching their maximum destructiveness in 1908.

As soon as the hops began pushing through the ground the beetles were observed swarming around the vines, giving the soil in the immediate vicinity a black, metallic appearance. These swarms of flea-beetles devoured the hop shoots as fast as they appeared, and in places where the vines were a foot or more on the string the attack was so severe that in a few days the field looked as if it had been burned over. This infestation resulted in a loss of about 75 per cent of the crop in the Chilliwack and Agassiz valleys.

FIG. 8.—The hop flea-beetle (*Psylliodes punctulata*): Eggs. Greatly enlarged. (Original.)

LIFE HISTORY.

THE EGGS.

Descriptive.—The eggs of *Psylliodes punctulata* (fig. 8) are one-third of a millimeter long, about one-half as wide, ellipto-cylindrical in shape, and quite yellow in color. They are very hard to distinguish, unless in clusters, without the aid of a hand lens, and when mixed with soil it is almost impossible to find them.

Where laid.—Beetles which were confined in lamp-chimney breeding devices were observed to oviposit upon hop leaves and pieces of paper and upon the sides and bottoms of the chimneys. One morning, upon moving a cage which had a cheese-cloth base, the writer discovered several hundred eggs which had been deposited between the cloth and the table. As this appeared to be an excellent way to obtain eggs in large numbers, several cages were accordingly fitted up, and to make conditions as natural as possible, were placed over moist soil. Hundreds of eggs were obtained in this manner and were in a very convenient situation for handling. In order to obtain eggs under more natural conditions, large numbers of beetles were confined in tin cylinders which had been sunk in the soil inclosing the roots of a vine. Two weeks later when the soil in these cylinders was examined, eggs were found 1½ to 2 inches below the surface. A few single eggs laid in the field were observed near the base of a

vine and about 1½ inches down in the soil. Although conditions such as the looseness and water content of the soil may cause a variation in the depth, and the lack of cultivation, in the distance that they are placed from the vine, the above is probably the average position for the eggs deposited in the field.

Arrangement.—Eggs obtained under laboratory conditions were deposited both singly and in clusters of from 2 to 8, but with no regular arrangement. All the eggs which were observed in the field were found one in a place, but some of them are probably laid in clusters under natural conditions.

Conditions favorable for incubation.—The eggs which were found in the field were in moist soil, and those which were kept under like conditions in the laboratory hatched in due time. On the other hand, eggs which were allowed to dry soon died and shriveled up. A moist, warm soil appears to be the most favorable condition for incubation.

Time of incubation.—Several hundred eggs which were obtained on the cheese cloth were placed in black satin bags and buried in moist soil, both in the laboratory and in the hopyard. These eggs required from 19 to 22 days to incubate; those in the field hatched a little sooner than the ones in the laboratory. This difference in time may be explained by the fact that the soil in the yard was heated by direct sun rays, while that in the laboratory was not.

Hatching process.—The eggs of this beetle change but little in general appearance during the first thirteen days of incubation. After this period a transparent place appears near one end, and a few days before hatching this spot turns dark. In emerging, the larva evidently breaks its way out through the side of the egg, for a longitudinal slit was observed in all empty eggshells.

THE LARVA.

Description.—When it first emerges from the egg the larva is a delicate, slender, white, grublike creature, about one-half millimeter in length. After a few hours it turns gray, the head darkens, and a dark patch appears on the last segment of the abdomen. The larva (fig. 9, *a*) grows slowly, passing through several molts, and when full grown is about 5 millimeters in length and three-fourths of a millimeter in diameter. When it first emerges from the egg it is very active and crawls through the soil at a rapid rate, but as it grows this activity gradually decreases, and when the last stage is reached it is little able to crawl about.

Length of larval stage.—To determine the length of the larval stage, many beetles were confined around hop vines, in an uninfested area, for three days and were then removed. When observed at a later

date larvæ were found in the soil, and when these were apparently ready to pupate some of them were placed in vials of soil and observed daily. A few of these larvæ pupated and from these data the length of larval life was found to be about 35 days. This time checks up very well with the other observations made in the field.

Pupation.—This insect does not form a distinct pupal cell, as is the case with some other coleopterous larvæ, but when full grown ceases to feed, contracts greatly in length, and enters a long somnus, the prepupal stage. The larva remains in this stage from 11 to 14 days, and then transforms to a true pupa (fig. 9, *b*, *c*) with free appendages.

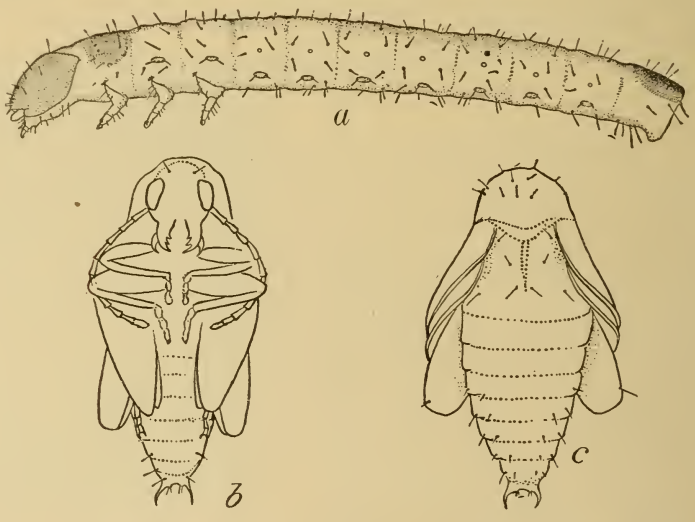


FIG. 9.—The hop flea-beetle: *a*, Larva; *b*, pupa, ventral view; c, pupa, dorsal view. Much enlarged. (Original.)

THE PUPA.

Description.—When the pupa is formed it is pearly white in color and is much like the adult beetle in form. The sheaths for the adult appendages are free from the body, and the legs, wing-pads, and antennæ, although folded up, may be easily distinguished. The pupa of this flea-beetle is not very delicate, as was shown by the fact that a number of them were removed from the soil for daily examination during a period of eight days, without injury.

Duration of stage and transformation to adult.—The true pupal stage lasts on an average 16½ days. The first evidence of transformation is the appearance of color in the eyes; then gradually the mandibles, tibial joints, and antennæ become dark in color, the legs turn light brown, and the elytra move to the back. When this condition is reached the beetle is able to crawl about. It does not get out of

the soil, however, until the head, thorax, and elytra have colored, which requires from 12 to 14 hours. The beetle is then of a dull blue-black color, but after it has been in the sunlight for a few days it becomes quite bronzy in appearance.

FIG. 10.—The hop flea-beetle: Adult beetles, showing relative sizes of female and male. The male has the wing covers slightly spread. Much enlarged. (Original.)

THE ADULT.

The adult is a dark, smooth, bronzy-black beetle of the family Chrysomelidæ, one-twelfth to one-tenth of an inch (1.5 to 2.5 mm.) long and about half as wide. The male and female are alike in general appearance except as to size, the male being distinctly smaller than the female (see fig. 10). The hind thighs, by means of which the beetle jumps, are strongly developed, hence the name "flea-beetle." The specific name *punctulata* refers to the punctulate or pitted condition of the head, thorax, and elytra. This beetle should not be confused with *Epitrix subcrinita* Lec., sometimes collected with the hop flea-beetle on potatoes, which, although much like *Ps. punctulata* in general appearance and in the possession of the punctulate condition of the thorax and elytra, is smaller and is covered with hairs.

FIG. 11.—The hop flea-beetle: Ovipositor of female. Highly magnified. (Original.)

Time of reaching maturity.—After the adult has emerged from the pupal state between 12 and 24 hours are required for coloring and, perhaps, as much longer for it to work its way out of the soil. Beetles which appeared to be not over 4 days old were found in copula and, judging from these very unsatisfactory data, about 6 days would be required for the beetles to become fully mature.

Copulation.—Copulation was observed at all times of the day and even at night. Morning seems to be preferred, for more pairs were observed between 8 and 12 o'clock than in the afternoon. Although some remained together but a short time, others required three-fourths of an hour, and one pair which was closely watched took 50 minutes for the operation. As long as there were beetles in the field pairs were to be found, and Mr. Hulbert states that he has observed them in copula up to the time that they went into hibernation in the fall.

Oviposition.—When ready to oviposit, the female works her way down into the soil until she reaches the moist layer, where she lays her quota of eggs. Although this operation of egg-laying was not observed, the fact that the eggs were deposited through cheese cloth and even light cotton cloth leads the writer to believe that the long ovipositor (fig. 11) is worked into the firm soil before oviposition. The eggs would thus be concealed to some extent from predaceous enemies.

Number of eggs and rate of egg-laying.—Beetles captured in copula and confined in vials laid from 4 to 18 eggs. Three pairs copulated again after ovipositing, but only one female laid eggs after this second copulation. Table I illustrates the number and rate of egg-laying as indicated by beetles kept under laboratory conditions:

TABLE I.—*Number of eggs and rate of egg-laying of the hop flea-beetle.*

Adult No.	Dates of copulation.	Dates first eggs were laid.	Number first eggs laid.	Dates second eggs were laid.	Number second eggs laid.	Death.
	1909.	1909.		1909.		1909.
1	April 22 and May 2	May 1	13	May 3	5	(a)
2	May 4	May 10	6			May 20.
3	June 4	June 8	2	June 9	10	June 19.
4	June 4 and 9	June 9	11			June 14.
5	do	do	11			June 16.
6	June 4	do	1	June 9	7	June 19.
7	do	do	14			June 15.
8	do	June 10	9			June 16.
9	do	do	18			June 15.
10	do	June 12	10			June 16.
11	do	do	4			June 19.

a Lost.

Length of life of the beetle.—The length of life of the hop flea-beetle is quite variable. Several lots of newly emerged insects which

were brought into the laboratory died within a week. Another lot, brought in May 11 and placed in a lamp chimney, lived well into July, the last individual surviving until August 22. This was an exceptional case, the average length of life being between three and six weeks.

HABITS.

THE LARVA.

Where found.—Most of the larvæ were observed to be within 18 inches of the base of the vine, the number increasing as the vine was approached. A few, however, were taken between the rows, among the roots of chickweed and lambsquarters, and even in well cultivated parts where no weeds were growing. The surface soil of the hopyards is filled with delicate rootlets (fig. 12) and the larvæ find sufficient food almost anywhere.

FIG. 12.—Filamentous roots of hop vine on which the hop flea-beetle larvæ feed. (Original.)

Depth in soil.—In order to determine the average depth at which the younger stages may be found, the earth was taken up around the base of a vine in 3-inch layers, and the larvæ in each layer counted. The results are as follows:

Depth of soil.	No. of larvæ found.
1–3 inches	6
3–6 inches	21
6–9 inches	7
9–12 inches	1

Although some few may be found above and some below, from 2 to 7 inches is the depth at which one may expect to find the majority of the larvæ.

Conditions favorable.—The soil in which the larvæ were found varied from a light sandy loam to a very heavy, almost adobe condition.

The moisture conditions which are favorable were determined in the laboratory. The larvæ lived in soil that was quite wet, but when it was saturated they were drowned. On the other hand, a slightly moist soil seemed most favorable, and when it dried out they soon died. Any soil with a moderate moisture content appears to be favorable for the growth of the larvæ, the texture having no influence whatever upon them.

Food.—The majority of larvæ are located close around the hop vine where the soil is filled with tender filamentous roots (fig. 12). A few, however, were found around the roots of lambs-quarters, chickweed, and mangel. All of these tender rootlets, and perhaps many others, are fed upon by the larvæ.

THE ADULT.

Food plants.—The hop flea-beetle has been observed feeding upon a large number of plants. Some of these are distinctly preferred; others are accepted after the beetles have fed upon the hop or mangel; and still others are attacked in the field, but not after the insects have eaten of their preferred food plants.

A series of experiments was conducted to determine which plants were preferred and their order of preference. Beetles were confined on several species of plants, and each day when fresh food was supplied the species which was eaten the most was left out. Thus by elimination the order of preference was obtained. This order for beetles captured on the hop was found to be quite different from that for beetles captured on the mangels, as is shown by the following list:

TABLE II.—*Food plants of the hop flea-beetle.*

In order of preference of beetles taken from the hop.	In order of preference of beetles taken from the mangel.
Hop (*Humulus lupulus* L.).	Nettle (*Urtica dioica* L.).
Nettle (*Urtica dioica* L.).	Rhubarb (*Rheum officinale* Baill.).
Tomato (*Lycopersicum esculentum* Mill.).	Radish (*Raphanus sativus* L.).
Mangel (*Beta vulgaris* Moq.).	Mustard (*Brassica nigra* L.).
Radish (*Raphanus sativus* L.).	Lambs-quarters (*Chenopodium album* L.).
Mustard (*Brassica nigra* L.).	Mangel (*Beta vulgaris* Moq.).
Lambs-quarters (*Chenopodium album* L.).	Hop (*Humulus lupulus* L.).
Watermelon (*Citrullus vulgaris* Schrad.)	Watermelon (*Citrullus vulgaris* Schrad.).

SECOND CLASS.[a]

Rhubarb (*Rheum officinale* Baill.).
Potato (*Solanum tuberosum* L.).
Pigweed (*Amaranthus retroflexus* L.).
Dock (*Rumex obtusifolius* L.).
Sorrel (*Rumex acetocella* L.).
Red clover (*Trifolium pratense* L.).
Tomato (*Lycopersicum esculentum* Mill.).
Potato (*Solanum tuberosum* L.).
Pigweed (*Amaranthus retroflexus* L.).
Red clover (*Trifolium pratense* L.).
Dock (*Rumex obtusifolius* L.).
Sorrel (*Rumex acetocella* L.).

Finding that the beetles did not care for certain plants after they had fed upon hop or mangel, an attempt was made to starve them to the food which was apparently most disliked. A large number of beetles were accordingly confined with red and white clover and with sorrel. Although the blossoms of the white clover were slightly attacked, the beetles finally starved to death on these plants.

Portions of plants attacked.—During the spring and early summer the beetles fed upon the shoots and tender buds and ate holes the size of a pin head in the leaves. (See Plate III.) In cases where the leaves were very thick the lower surface tissues were left. These, however, soon dried and fell out, leaving a clean hole which, as the leaf expanded, became larger, sometimes reaching one-fourth of an inch in diameter. In feeding upon the hop plants, the beetles dug small pits in the shoots, which when the attack was severe caused the death of the stem. In the fall the beetles climb the trellis poles and crawl along the vines until they reach the hop cones, of which they are very fond.

Destructive power by feeding.—When the beetles appear in large numbers they will devour a plant completely. In the spring of 1908 they kept the yards bare until the last of June or the first of July, and when the mangels were coming up the beetles damaged them so severely that one planter found it necessary to sow three times in order to get a stand. In the fall, after the hopyards were cleaned up, the beetles migrated to the nettles along the fences and completely devoured them. The beetles were at this time in exceptionally large numbers; under ordinary conditions their attack is not so severe.

Activity and migrations.—The flea-beetles that have just emerged are soft and sluggish and are readily picked off of the vines with the fingers. Within a few days, however, they become very active and it is then almost impossible to catch them in the hand. During the spring and summer of 1909 the beetles migrated little, if at all. The infested regions did not enlarge or change from the time that the beetles appeared in the spring until they disappeared in July. The

[a] Plants of the second class are eaten very slightly, unless the beetles are starved to them.

insects were not observed to leave the vines unless disturbed, and the probability is that unless the food gives out they do not migrate during this season. It has been repeatedly observed by the hop growers of Chilliwack and Agassiz valleys that yards which were badly infested one summer would be almost free from beetles the next, while the adjoining yards which were not attacked the preceding season would be severely damaged. One explanation of this is that the beetles, having eaten up all the food remaining in the yards after the vines have been burned, migrate to the adjoining block, hibernate there, and emerge in the spring. As the beetles were not observed moving about during the spring and summer this is the only probable time of migration.

Activities at night.—The beetles go into the bud scales or down under the clods at the base of the vine on cold nights, but when mild weather approaches they remain on the leaves. They were observed to move about slightly, but are very much less active than during the day.

Flight.—When disturbed during warm weather the beetles occasionally spread their wings as they jump, and fly back to about the same place they started from. General flight is seldom indulged in, but during the last of April those which were disturbed by the Bordeaux spray circled around at an elevation of about 4 feet for a few minutes, then settled down. This was the only time when beetles were observed on the wing.

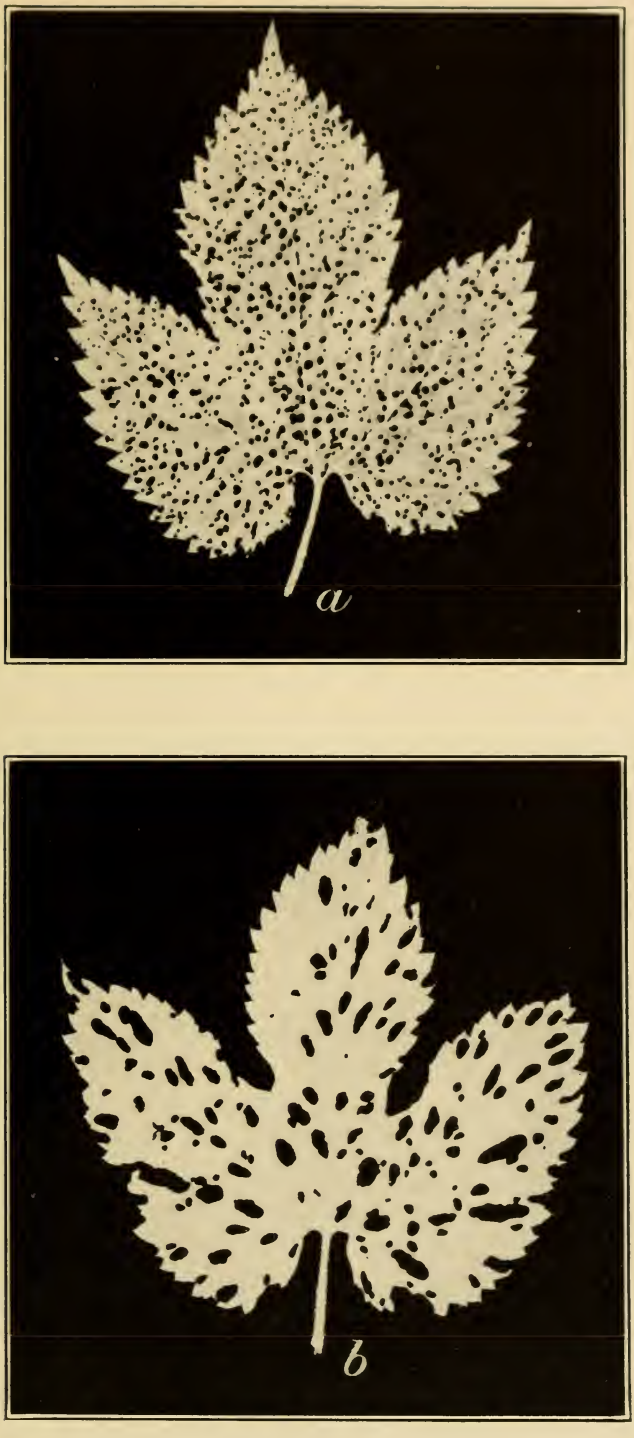
Protection by concealment.—On cold spring days some of the beetles crawl down into the opening buds of the hop or nettle. Here they are protected from the weather and may feed upon the tender buds which are their choicest food. When the leaves have expanded beetles will be found on the under surface, and in very cold weather under the clods at the base of the vine. Although some are thus concealed during the active season, the majority remain on the upper surface of the leaves.

Protection by locomotion.—When disturbed the beetles jump from the vine and fall among clods or rubbish where they are not readily seen. They do not feign death as some other beetles do, but spread out their legs, right themselves, and after a short pause, begin slowly to move about. The distance that they jump depends somewhat upon the height from which they start. Horizontally they can leap about a foot and a half, and about 10 inches in a vertical direction.

SEASONAL HISTORY.

LENGTH OF LIFE CYCLES.

Judging from observations on the appearance of beetles in the field, the lengths of the life cycles of the spring and summer genera-



HOP LEAVES, SHOWING EFFECT OF ATTACK BY THE HOP FLEA-BEETLE (PSYLLIODES PUNCTULATA). (ORIGINAL.)

tions are about equal. In order to obtain the entire life cycle, the 6 days' interim between the emergence of the beetles as adults and copulation, and also the 6 days required for the eggs to mature, must be added to the 72 days which are passed in the egg, larval, and pupal stages. In adding these, we have 84 days, or 12 weeks, as the length of the life cycle.

NUMBER AND TIME OF APPEARANCE OF BROODS.

There are two distinct broods of beetles in the Chilliwack and Agassiz valleys. One emerges in the early spring and the other in the latter part of July or the first part of August.

The first generation appeared very suddenly and in large numbers between April 25 and May 10. The appearance and devastation in the Agassiz yard was particularly startling. On April 24 the vines in this yard were almost ready to train onto the string and were only slightly damaged by the beetles. April 28 this yard was literally alive with the "fleas," in some places there being as many as 50 or 60 to the vine. The leaves were entirely eaten away and many of the terminal buds were killed. Although this did not ruin the shoot, it caused a very undesirable branching. Beetles continued to emerge at Chilliwack in large numbers until about May 10, after which only a few belated individuals came out.

The first and second generations are very distinct. The first brood was in its maximum numbers about the 1st of June, but after this the insects gradually diminished and had entirely disappeared by July 20. The second generation began to emerge about the 25th of that month, but were not present in large numbers until about August 10. These beetles live through the fall and winter, emerge in the spring, and deposit the eggs which produce the first generation of the next season.

MULTIPLICATION.

According to observations made upon the number of eggs and rate of egg laying, the maximum number of individuals coming from a single pair in the first generation would be 18. If all of these survived and produced the maximum number again, the second generation would amount to 162 beetles. The average number of eggs laid may be below 18, and a large number of larvæ are destroyed by predaceous enemies in the soil, so that the few beetles which winter over will not necessarily produce an overwhelming number in the second generation.

HIBERNATION.

ENTRANCE INTO HIBERNATION.

When cool weather comes in the fall the beetles begin to hibernate. They do not travel far from where they chance to be, but enter the

first favorable place that they find. This early hibernation is usually temporary, and when the first warm day comes they emerge from their hibernating places and hop around on the ground, retreating again when it becomes cool.

PLACES OF HIBERNATION.

During the winter the beetles were observed hibernating in cracks in the trellis poles, under the string of the string pegs, in the hollow vine stubs, in the grass and weeds, and in the soil.

Beetles in poles.—The beetles were first observed to be hibernating in the trellis poles. By lifting the slivers they were found wedged between the slivers and the solid wood, some were dug from rotten, porous portions of the poles, and a few were observed under the bark. Many were found in the deep cracks, but the largest number were under the slivers and in the rotten wood. As shown by Table III the majority of beetles hibernated close to the ground. They accepted the first shelter that they came to, and some even entered slivers and crawled down below the surface of the soil.

TABLE III.—*Position of hop flea-beetles in the poles.*

First foot	182
Second foot	152
Third foot	79
Fourth foot	33
Fifth foot	4
Sixth foot	6
Seventh foot	0
Total number of flea-beetles	456
Number of poles counted	74
Average number of beetles per pole	6.16

In November, 1908, several poles were taken into the hop kilns and heated in order to bring out the beetles that were hibernating therein. Most of the poles contained small numbers of them, but in one badly splintered pole were found 490 beetles. These results led the hop growers to believe that a large majority of the hibernating beetles were in the poles. In investigating this point the writer had four average poles taken into the kilns and heated. Only 19 beetles were found in these 4 poles. These, together with other results obtained from extensive field counts, proved conclusively that the number of beetles which were hibernating in the trellis poles was not dangerously large.

Beetles in the vine stubs.—The hollow vine stubs which are left when the vines are cut and burned in the fall are very favorable hibernating places, and as many as 16 beetles have been found in a

single stub. Many stubs do not contain beetles, however, and the average is very much lower. A few beetles were found in the cracks of the pith of pigweed and in some hollow-stemmed plants, but the most frequented place of this sort is the hollow vine stub. Table IV illustrates the number and condition of the beetles in the stubs:

TABLE IV.—*Number and condition of hop flea-beetles taken from vine stubs.*

Date.	Number of stubs.	Number of beetles found.	Average number of beetles per kiln.	Average number of beetles per acre.	Number of beetles dead.	Number of beetles alive.	Per cent dead.	Per cent alive.
1909.								
February 1	219	354	10.01	8,908.90	.....	.....	.....	.....
Do	89	216	7.32	7,517.47	.....	.....	.....	.....
February 4	320	334	.....	.....	118	216	35.32	64.68
February 10	340	265	2.31	2,057.90	97	243	28.81	70.19
February 20	324	93	.88	783.20	37	56	39.78	60.22
Do	330	133	1.23	1,094.70	61	72	45.86	54.14
March 1	457	813	7.08	6,301.20	292	521	35.88	64.12
March 8	161	331	8.20	7,298.00	106	225	32.02	67.89
March 9	241	327	5.40	4,806.00	137	188	42.20	57.80
March 10	288	397	5.48	4,877.20	108	289	27.20	72.80
March 16	231	323	5.56	4,948.40	114	209	35.29	64.71
Do	155	292	7.42	6,603.80	118	174	40.41	59.59

Beetles in string pegs.—The cedar pegs which are used in stringing the yards are usually left in the field when the yards are cleaned up in the fall. The soft string which often remains on the peg affords a splendid place for the beetles to spend the winter, and many were observed taking advantage of it.

Beetles in grass and weeds.—In the grass and weeds of uncultivated yards and along the borders of other yards the beetles were found hibernating in considerable numbers. They were situated just under the surface of the soil, but above the crown of the roots. They probably seek the grass and weeds as a temporary refuge when the cold weather first sets in, and as the winter advances they either crawl down into the soil or it is washed over them by the early rains.

Beetles in the bare soil.—Many beetles were found around the poles and vines embedded in the bare soil. In one strip of soil 3 inches wide surrounding a trellis pole, 31 beetles were found; many were observed in the soil around the base of the vines and a few between the rows. They did not penetrate very far into the firm soil, the majority being found within the first half inch, but where the land was in the form of loose clods at the time that the beetles entered they crawled as far down as the openings went, and the rain, packing the soil over them, housed them 2 and even 3 inches below the surface.

Method of finding beetles in the soil.—Since the beetles are very small and dark in color they are very similar to the particles of soil in which they are embedded, and to find them by digging around the roots of the grass is almost impossible. An attempt was made to

screen them out by washing the soil through cheese cloth. This was quite possible, but very slow, and while screening them out the writer observed the beetles floating on the surface of the water. This discovery suggested a very simple method of separating them. The soil was placed in a screen-wire box and washed in a pail of water. This broke up all lumps, and the beetles floating to the top were picked up with a pair of forceps.

EMERGENCE FROM HIBERNATION.

Artificial emergence.—In anticipation of the emergence of the hibernating beetles some experiments were conducted to determine the temperature at which they might be expected to appear and their actions when forced from their natural winter quarters. Beetles taken from frozen string-pegs were placed in lantern chimneys and beginning with 28° F. the temperature was gradually raised and the actions of the beetles noted. At 40° the antennæ began to move slightly; between 40° and 50° the beetles moved about slowly and if disturbed would jump a short distance. Between 55° and 60° the beetles were quite active and crawled around in the lantern chimney. Their activity increased as the temperature was raised until 105° was reached, at which point they gradually became inactive again. Table V illustrates the effect of temperature upon the beetles, beginning with that of the room and increasing to 146°. In this experiment the beetles were confined in a double tube with an air space between and the temperature was raised gradually.

TABLE V.—*Emergence and activity of the hop flea-beetle in artificial temperatures.*

Date.	Number of insects.	Room temperature.	Temperature reduced to—	Greatest activity at—	First dead at—	Last dead at—	Time of experiment.
1909.		°F.	°F.	°F.	°F.	°F.	*Minutes.*
March 12	10	56	56	90	82	140	15
March 1	10	56	56	90–100	90	146	15
Do	8	56	56	90–100	110	126	10
Do	10	56	56	98–100	114	138	20
Do	10	58	58	90–100	95	139	20
April 12	10	56	56	60–70	78	110	5
Do	10	56	56	80–90	90	148	25
Do	10	57	57	.....	110	.....	.....

When beetles were thawed out they all became active between 40° and 45° F. When the higher temperatures were reached, however, there was a considerable difference in their susceptibilities to the change as may be seen by referring to Table V. Some of the beetles which were forced from hibernation were placed, on January 27, in a cage containing a young nettle plant. On February 8 several holes

the size of a pin head were observed in the nettle leaves and these beetles continued to feed until spring. The majority of the beetles were active whenever the cage was in the light and the temperature above 50°. They became inactive only when darkness approached or the temperature fell below 40°. The beetles were not observed to seek hibernating places when artificially emerged, unless conditions were unfavorable to activity. When put in a cool, dark place many of the beetles entered hollow vine stubs and pieces of corrugated paper which were placed in the cage for this purpose. Some, however, were content with the cloth top and the glass sides of the cage for a hibernating place.

Natural emergence.—On March 9 four beetles were seen crawling around on the sunny side of a trellis pole. These were the first that were observed emerging in the field. When warm days became more frequent the beetles appeared in numbers and fed upon the young nettles. They were very active and were observed copulating during the warmer part of the day, but when evening came they disappeared from view and did not come out again until the frost was all melted the following morning. Although some beetles emerged during the warmer days of March, the maximum number did not appear until April 15. After this they gradually diminished in numbers and by the 10th of May had nearly all disappeared.

DISEASES.

FUNGOUS DISEASES.

Many of the beetles that were found dead in the hollow vine-stubs were covered with a white mycelium. When these beetles were placed in a moist chamber *Penicillium glaucum* and the hop-mold *Sphærotheca castagnei* developed.

No other fungous growths were observed by the writer, but Dr. C. S. McKee, of Vancouver, British Columbia, in a letter regarding some of his experiments with the hop flea-beetle, mentions a fungous disease in the following words: "Before they began to die they were distinctly less active, and even before death some of them could be seen to have a fungous or mouldy growth on them, particularly under the wings." Doctor McKee does not state what this fungus was, and it is quite possible that it was a Penicillium, as was found on the beetles in the field. Although Penicillium is known, under some circumstances, to become parasitic, the probability is that the beetles died from some other cause and that the fungus entered as a saprophyte.

BACTERIAL DISEASES.

Beetles which were brought into the laboratory between the 10th and 14th of June died off in large numbers. They had a very sour odor about them which was not noticed around beetles which died earlier in the spring. This great mortality, accompanied by the sour odor, indicates the possible existence of a bacterial disease. An endeavor was made to determine this point, but the beetles in the check cages died as rapidly as those which were exposed to infection, and no conclusion could be drawn.

PARASITES AND PREDACEOUS ENEMIES.

No parasites attacked the beetles during the spring generation, and none has so far been observed on beetles in British Columbia.

Although the adults have no known predatory enemies, with the possible exception of some birds, the younger stages, especially the larvæ, are subject to the attack of several creatures. The larva of one of the Carabidæ was quite plentiful in the soil, and under laboratory conditions was observed to feed voraciously upon the flea-beetle larvæ. Two species of centipedes were also numerous, but only one was observed feeding upon the larvæ. This species was very common in the hopyards and probably destroyed a large number of beetle larvæ.

CONTROL MEASURES.

The fact that the beetles hibernate in the soil as well as in the poles, vine-stubs, and string-pegs, that the younger stages are all passed beneath the surface of the soil, and that, when they emerge, the adults are not readily killed by arsenicals or by contact insecticides, made the control problem at first appear to be a difficult one. During the spring and summer every feasible method of control was carefully tested, and of the following measures the application of tanglefoot and, under some conditions, the use of the sticky shield have proved to be the key to the flea-beetle problem.

THE TARRED BOARD OR STICKY SHIELD.

The hibernating beetles, unless in unusually large numbers, will not require any attention, but the sudden appearance of the first generation just before the vines are trained may require the use of the tarred board or sticky shield.

The tarred board which was used during the spring of 1909 was made by stretching a piece of 8-ounce canvas over a light wooden frame, 4 feet long by 3 feet wide. A 4-foot strip attached to the

middle of the board and braced by an upright to the rear edge forms a handle. The canvas was then coated with tar; hence the name "tarred board."

During the first part of the season a tarred board was placed on each side of a vine and the beetles jarred off with a bunch of grass. This was slow work, and it was found by actual count that 85 per cent of the beetles that were on the vines could be captured by placing a single board on the leeward side of a vine. The beetles are thrown onto it with a single sweep of a large brush (Pl. IV, fig 1). This method reduces the cost of going over the field one-half, and twice the acreage can be relieved in the same length of time.

Although effective as a flea-beetle catcher, this tarred board is a heavy and awkward thing to handle. A light shield which promises to be as efficient as the heavy tarred board is made of light galvanized iron, 3 feet wide and 2 feet high, the top of the iron being tacked around a curved board to hold it in shape. A piece of screen wire is fastened on the inside to prevent the oil from running down, and to make it fit close around the base of the vine a curved notch is cut in the bottom. The shield is operated by means of a hose-covered wire handle which is attached between the center of the iron and the middle of the top board.

The handle is held in the left hand, and, steadying the shield with the right, the notch is placed close to the base of the vine. Then, holding the shield at an angle of about 45°, the beetles are brushed onto the screen with a large feather duster (Pl. IV, fig. 2).

Brushes.—During the first of the season many sorts of brushes were tried. Leafy birch twigs made a very effective brush, but did not last long; grass was not rigid enough, and broom straw was too stiff. The best green brush was made of young fir or cedar boughs. These form a screen as well as a brush and last all day. Cutting twigs and making brushes, however, becomes expensive, so that a large feather duster proves to be cheapest in the end.

TARRED SLEDGES.

When the second generation of beetles appeared in 1908, tarred sledges 8 feet long and wide enough to fill the spaces between rows were used to advantage. Eight or 10 of these sledges drawn by horses were run parallel with each other and the beetles jarred down upon them. A lighter sledge (fig. 13), drawn by a man, was devised in 1909, but since the tanglefoot has proved so effective this sledge is unnecessary.

Crude oil or tar.—Both crude oil and tar are effective when used on shields or sledges. Tar has more disadvantages, for on cold days it is very thick and on warm days dries rapidly, and in either condi-

tion may not catch the "fleas." On the other hand, the oil is always sufficiently liquid and does not dry. Neither substance injures the vine, and, although crude oil is the most satisfactory, the tar does very well.

BANDING WITH TANGLEFOOT.

It was observed during the season of 1908 and also in 1909 that the beetles did not fly or jump upon the vines, but crawled up the stems. This fact suggested the possibility of keeping them down by means of a sticky band, and a number of experiments were conducted along this line.

FIG. 13.—Hindoo using tarred hand sledge for capture of hop flea-beetles. (Original.)

Fearing that the tanglefoot might injure the tender vines if it was applied directly to them, cotton was first wound around the stems and the tanglefoot smeared over that. The bands were placed 2 feet from the ground, and all near-by leaves removed to prevent the formation of a bridge. Two weeks later the leaves below the bands and all of the leaves of unbanded vines were completely riddled by the beetle, while the leaves which were above the bands were untouched (fig. 14).

It was found that the tanglefoot does not injure the epidermal tissues and can be applied to the most tender vines. This fact has

FIG. 1.—HINDOO USING TARRED BOARD AND EVERGREEN BRUSH TO DESTROY HOP FLEA-BEETLES. (ORIGINAL.)

FIG. 2.—METHOD OF USING LIGHT STICKY SHIELD AND FEATHER DUSTER IN COMBATING THE HOP FLEA-BEETLE. (ORIGINAL.)

greatly simplified the operation and has made banding much more practical.

Since the beetles can not crawl over the bands the vines are perfectly protected. In case the beetles are numerous when the vines are first trained, the tanglefoot may be applied at that time, or if the beetles are not troublesome during the first generation it may be applied after the vines are stripped so it will be ready for the second brood. In that case, however, the poles must be banded as well as the vines, for the beetles have a habit of climbing the poles and crawling along the wires, where they do much damage to the hop cones.

Effect upon the beetles.—The tanglefoot bands not only keep the beetles off of the vines but a large number of them are caught in it. In places where the beetles were very thick, hundreds of them became entangled in it and in some instances so many got caught that they formed a bridge over which the others crawled. Beside being killed by coming in contact with the tanglefoot, many are starved to death by being kept away from the hop-leaves. This was especially true in the yards that were kept well cultivated and all suckers cut away. If the weeds are not allowed to grow in the yards and the vines and poles are well banded, most of the beetles will either be caught in the bands or starved to death, the remainder going into winter quarters in such poor condition that there will be few beetles the next spring.

FIG. 14.—Banded hop vine, showing condition of leaves above and below the band. (Original.)

Application.—It is necessary to get the tanglefoot well into the spaces between the two vines, the simplest way to accomplish this being to apply it with the hands. A section about 6 inches long should be coated with the tanglefoot, care being taken that no parts are missed and that no leaves are left to form a bridge across it. A strip around each pole about 3 feet from the ground should be trimmed off with an ax, so that the tanglefoot may be applied easily. A small paddle about 2 inches wide is the best thing with which to apply the tanglefoot to the poles, for only a narrow band is needed there. The amount of tanglefoot used per acre varies according to the number of poles and vines. In one yard where the trellis poles

were rather close together, 10 pounds were used to the acre. Although the tanglefoot is apparently very disagreeable material to apply, it is easily washed off the hands with a little kerosene or even with soap and hot water.

DESTRUCTION OF HIBERNATING BEETLES.

In poles.—Since a large number of beetles were found hibernating in places where they might be attacked, it was believed advisable to destroy them. The slivers on the trellis poles, under which the beetles were hibernating, were struck with an ax, forcing them back

FIG. 15.—Killing the hop flea-beetles in the poles. (Original.)

against the solid wood, and thus either crushing the insects or jarring them out. A tarred board was made which fitted close around the base of the pole and caught all the beetles which fell down (fig. 15). The rotten parts of the pole were chopped off and burned. Any beetles which fell out during this operation were caught on the tar, and the fire destroyed the rest. This is the most practical way of killing the beetles in the poles, as it is cheap and very effective.

In vine-stubs and string-pegs.—As stated under the head of "Hibernation," the vine-stubs and string-pegs, which are usually left in the field when cleaning up in the fall, may shelter a considerable number of flea-beetles. In order to determine whether or not the

number present in such places is sufficient to warrant their destruction, two hundred or more of these should be gathered, the beetles counted, and the average number of beetles per hill determined. If the number of beetles found will warrant the expense, the vine-stubs and string-pegs should be gathered during the cold weather and burned. In case the temperature is above 40° F. the stubs and pegs should be collected into tarred buckets to prevent any beetles from escaping. Below 40° the beetles are inactive and this precaution is unnecessary.

BORDEAUX MIXTURE.[a]

Bordeaux mixture has long been recommended as a deterrent against flea-beetles, and, should the overwintering adults severely attack the young hop-shoots, may prove quite effective against the hop flea-beetle. During the spring of 1909, when the hops were coming out of the ground, an infested region was thoroughly sprayed with the 5–5–50 formula, several rows being left as checks. Unfortunately wet weather followed, which, while it favored the growth of the hops, held the beetles back so that no definite conclusions could be drawn.

The Agassiz hopyards, at the time that the beetles became numerous, were sprayed with the same formula. The Bordeaux mixture certainly deterred the beetles, but drove them to the growing tips, where they seriously damaged the terminal bud. This destruction of the terminal bud is very undesirable, as it causes the plant to force out arms close to the ground. Besides driving the beetles to the growing tips, the Bordeaux mixture burned the tender buds and also those leaves that were badly chewed by the beetles. Much damage was done in this way.

Since it was evident that the 5–5–50 formula was too strong, a series of experiments was conducted to determine the relative effectiveness of the 5–5–50, the 2½–10–50 Bordeaux mixture, and straight slaked lime, 15 pounds to the 50 gallons, as deterrents. Two-thirds of each vine chosen for this experiment was thoroughly sprayed with the various materials. A cloth cage was placed over each one, and a large number of flea-beetles were liberated inside. Five days after setting these experiments it was observed that, although the sprayed portions were slightly eaten, the unsprayed parts were decidedly preferred, the lime being as effective a deterrent as the strong Bordeaux mixture. Even though these experiments were fairly satisfactory, more work should be done along these lines at the time that

[a] For details in regard to the preparation of Bordeaux mixture the reader is referred to Farmers' Bulletin 243, entitled "Fungicides and their Use in Preventing Diseases of Fruits."

the hops are just coming up and during a season when the hibernated beetles are very numerous, in order to get more extensive results.

BORDEAUX-TOBACCO EXTRACT.

In endeavoring to combine a deterrent with a contact insecticide, the 5–5–50 Bordeaux mixture and blackleaf tobacco extract at the rate of 1 gallon to 65 gallons were mixed together. Vines were treated the same as in the previous experiment, and on examination after five days it was observed that the Bordeaux-tobacco mixture was as effective a deterrent as the Bordeaux mixture alone. Its insecticidal properties were tested by spraying a group of beetles which was placed upon a soil-covered cloth, and which, after being sprayed, was covered with a cage. After twenty-four hours 65 per cent were dead. In cases where the beetles are very numerous and a large percentage of them are around the vines, a Bordeaux-tobacco mixture should prove effective.

TOBACCO DUST.

In order to determine the value of ground tobacco as an insecticide, a large sheet was covered with a thin layer of soil, and on this was spread a ring of tobacco dust 1½ feet wide. A healthy lot of beetles was placed in the center of this ring, and the few that managed to cross were caught and placed in a cage. Most of the beetles perished in the tobacco dust, and those that crossed soon died. After the dew had caked the powder, however, all of the beetles which were placed in the center of the ring crossed the tobacco unharmed, even though some of them carried small pieces of tobacco with them.

Although the beetles are able to cross the caked tobacco, the insecticidal properties are not entirely lost, for when broken up and sprinkled onto the beetles it killed them as readily as the fresh material.

Application on mangels.—A large plot was selected in an infested mangel patch and the tobacco dust thoroughly applied. The following day only a few beetles were found on this plot, while the adjoining rows contained as many as ever. The tobacco dust is more effective on mangels than on hops, because the plants are close to the ground and can be more readily covered with the powder.

IMPRACTICAL MEASURES.

Against beetles in the poles.—Spraying with a distillate or some other contact insecticide was suggested as a means of killing the beetles in the poles, but the "fleas" are so far back in the slivers and so deep in the rotten portions of the wood that a spray will not

reach them. Painting the poles with crude oil or a thick crude-oil paint with the idea of blocking the beetles in was another suggestion, and several experiments were conducted along this line. Whiting was used as a filler and the poles were thoroughly coated with the mixture. This formed a sticky coating when first applied, but the oil was soon absorbed by the wood, and neither acted as a barricade nor a sticky trap for those that might crawl up the pole. At the time that the majority of the beetles were believed to be hibernating in the trellis poles, dipping them in hot crude oil was offered as a sure cure. This process, if properly handled, would probably destroy all the beetles that were in the poles, but the few present in that situation did not warrant such expense. A fumigatorium (fig. 16) was made which could be placed around a trellis pole, and many fumigation experiments were tried during the winter. When the thermometer was below 32° F. the beetles were apparently unaffected by the gases, and under field conditions the wind blew so hard that it was impossible to make the fumigatorium tight enough for effective work. Such a method, too, would require a great deal of time and labor, and as a practical control measure is out of the question. Several attempts were made to burn the beetles that were in the poles. In one experiment kerosene was painted on the wood and lighted, and in another an oiled gunny sack was lighted and wound around the base of a pole which was then inclosed in the fumigatorium. By the latter method a few beetles were killed, but as wood is such a poor conductor of heat few were heated sufficiently to injure them.

FIG. 16.—Fumigating trellis poles to destroy hop flea-beetles. (Original.)

Rolling the yards.—The fact that beetles were observed hibernating in the grass and just under the surface of the soil led to the suggestion that rolling the yards with a heavy roller would kill a large

number of them which happened to be in such locations. To determine this point 30 beetles were placed in each of three lamp chimneys and set over clumps of grass. As the cool evenings approached the fleas worked down into the sod, and before the frost was off of the grass the next morning a heavy roller was run over these clumps from three different directions. The lantern chimneys were then replaced and the sod taken into the laboratory. On examination only 2 injured beetles were found. Twelve in the first clump, 10 in the second, and 15 in the third were uninjured. The other beetles were not recovered and probably escaped during the rolling. A large block in one of the yards was rolled over at this time (fig. 17), but no difference could be seen between the number of beetles which emerged on the treated block and the number which came out on the rest of

FIG. 17.—Rolling the hopyards with heavy roller, as an experiment in the control of the hop flea-beetle. (Original.)

the field. The chitin of the hibernating beetles is very hard. The beetles are not readily injured when rolled between the thumb and finger, and it is very improbable that a satisfactory percentage could be killed by rolling the field in which the beetles are hibernating.

SPRAYING.

When the beetles became numerous on the sprouting hops, the possibility of the use of contact insecticides or of arsenicals was brought to the attention of the writer, and a number of sprays were carefully tested.

Blackleaf tobacco extract.—Flea-beetles which were thoroughly drenched with blackleaf tobacco extract at the rate of 1 gallon to 65 gallons of water soon died, but many beetles jumped through the

spray and escaped. This material did not hurt the tender vines, but the beetles were not killed unless they were completely covered with it.

Kerosene emulsion.—According to Professor Quayle's experiments of 1908, kerosene emulsion ranks next to blackleaf tobacco extract in effectiveness against this flea-beetle.

Whale-oil soap.—Whale-oil soap at the rate of 1 pound to 10 gallons of water was applied to hop "fleas" which were attacking mangels. When a beetle chanced to become the center of a drop of spray it soon died, but a little soap on one side or on its elytron did not injure it in the least.

Resin lye.—The resin-lye spray used at the rate of 1 pound of resin to 10 gallons of water was a little more effective than the whale-oil soap, but was far from satisfactory.

Arsenicals.—Although the hop flea-beetle is supposed to be very resistant to arsenicals, laboratory experiments proved that a fair percentage may be killed by the use of either arsenate of lead or Paris green. For good results the arsenate of lead should be used at the rate of 5 pounds to 50 gallons of water, and the vines should be kept well covered with it, but since the vines grow very rapidly such a method becomes too laborious and costly.

TRAPS.

Trap foods.—It is evident from the results obtained in the preferred food-plant experiments that the best trap food for beetles, either on the hops or on the mangels, is the nettle, the tomato for the hop and the rhubarb for the mangel coming next. Since the hop is preferred to any other plant, and since it comes up at the same time as the nettle, the only chance to use a trap food is in the fall after the hops are gone. The borders of the fields are the only places where a trap crop can possibly be grown, because, when the hops are gathered, the pickers would trample down anything that was growing between the rows. If the nettles which grow along the fences are thoroughly sprayed with arsenate of lead or Paris green about the time that the hops are picked a large number of beetles may be killed.

Trap lights.—The beetles which were brought into the laboratory appeared to be quite positively phototropic, and with the hope that trap lights might prove successful these were tried under field conditions. A lantern set on a tanglefooted board was placed in an infested mangel patch. Although the beetles were numerous on the mangels all around the light, only a few of them were attracted to it. They could be seen crawling around on near-by leaves, but apparently had no desire to approach the light. The same results were obtained with the acetylene light, the increased intensity having no effect upon the beetles.

Trap shelters.—The use of trap shelters to catch the hibernating beetles was one of the first control measures which were thought of.

The idea was to distribute them around the field while the beetles are still active and collect them as soon as the beetles hibernate. Under laboratory conditions beetles entered two sorts of traps very readily. The one is made by cutting the old vine stems into 6-inch sections and tying 8 or 10 of them into a bundle. The other trap is made of corrugated paper, with a plain sheet fastened on each side with marine glue. This leaves a row of tubes into which the beetles can crawl. Pieces 4 inches square were to be pegged out with slender pegs, but since other control measures have proved so effective the experiment has never been tried in the field.

CULTIVATION AND FERTILIZATION.

The earlier the hops come up in spring, the better chance there will be of their reaching the "string" before the beetles attack them. When the vines are once on the string they can be protected with tanglefoot bands or by the use of tarred boards.

Inasmuch as cultivation and fertilization tend to bring the vines up earlier in the spring they aid in the control of the beetles, and if clean cultivation is practiced after the vines are tanglefooted a large number of beetles will starve to death.

RECOMMENDATIONS.

The first knowledge that the hop growers will probably have of the presence of the hop flea-beetle in dangerously large numbers will be attack by the beetles upon the vines about the time that they are ready to train. The "fleas" at this time may be greatly reduced in numbers, so that the vines can reach the strings, by the use of the sticky shield (p. 49) or the heavier tarred board (p. 48).

After the vines are trained the beetles are readily controlled by the use of the tanglefoot bands. These bands should be renewed on the vines, and the trellis poles should also be banded at the time that the vines are tied in and stripped, or just before the appearance of the second generation. These tanglefoot bands form a perfect barrier to the insects. Even though the beetles are present in very large numbers they can not reach the upper parts of the hop vines, which can therefore produce a crop without molestation.

In order to starve the beetles the yards should be well cultivated and all suckers cut from the bases of the vines. If this is done the emerging insects will find very little to feed upon. In some cases the destruction of the beetles which hibernate in the trellis poles, string pegs, and vine stubs may be advisable, but if the banding is thoroughly done and the yards are kept clean during the growing season, very few beetles will live through the winter to attack the vines in the following spring.

U. S. D. A., B. E. Bul. 82, Part V. Issued August 31, 1910.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

BIOLOGIC AND ECONOMIC NOTES ON THE YELLOW-BEAR CATERPILLAR.

(*Diacrisia virginica* Fab.)[a]

By H. O. Marsh, *Agent and Expert.*

RECENT INJURY.

During the late summer and fall of 1909 there was a serious outbreak of the common yellow-bear caterpillar (*Diacrisia virginica* Fab.) in the upper Arkansas Valley of Colorado. Never before in the history of the valley had this species been so destructive, and the outbreak came as a surprise to all concerned.

The larvæ, or caterpillars, of the first generation developed normally on weeds along the fences and irrigation ditches and caused little damage to cultivated crops, but the larvæ of the second generation, which began to develop about the middle of August, were so numerous that the weeds were not sufficient to support them and they spread to sugar beets and other crops.

The sugar beets, because of the extensive acreage and the large supply of food which their tender foliage offered, were more severely damaged than any other crop. The larvæ were variously estimated to have infested from 15,000 to 20,000 acres of sugar beets in the upper portion of the Arkansas Valley. Definite records from this vast acreage show that fully 1,000 acres were badly defoliated.

The larvæ of this second generation developed so late in the season that the injury to which the beets were subjected did not noticeably reduce the tonnage, but all over the worst infested area there was a reduction in sugar content and quality. Owing to the other factors, such as late rains and a disease known as "leaf spot" (*Cercospora beticola* Sacc.), which also tended to lower the sugar content, anything more definite than an approximate statement concerning the loss of sugar in the beets would be very misleading. However, estimates based on comparative analyses made by the chemists at

[a] Formerly known as *Spilosoma virginica* Fab.

the various sugar factories indicated that there was a loss in sugar content of from 1 to 3 per cent over the badly defoliated area. Over a large part of the infested area the defoliation was not bad enough to cause any very noticeable loss.

The author's first observations in the Arkansas Valley on this species were made on July 23, 1909, at Rocky Ford, Colo., and the following is a summary of his notes at that place and at other points in Colorado and Kansas during the season. All notes, except when other localities are mentioned, were taken at Rocky Ford.

Before entering into a discussion of the biology, of the plants injured, of the experiments made, and of other matters, attention is called to the illustration (fig. 18) which shows the female moth, larvæ, cocoon, and pupa. This needs no further explanation than to state that the moth is of moderate size, its spread of wings

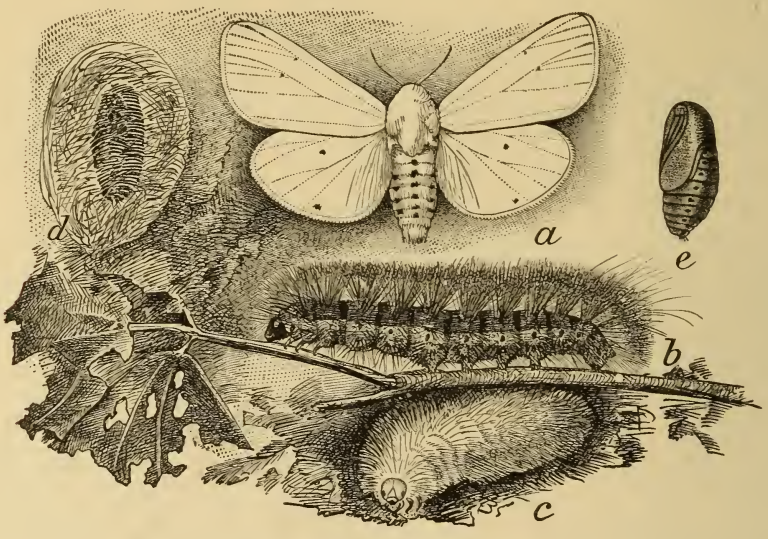


FIG. 18.—The yellow-bear caterpillar (*Diacrisia virginica*): *a*, Female moth; *b*, larva; *c*, pale form of larva; *d*, cocoon; *e*, pupa. (From Chittenden.)

being from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches, ornamented with black dots as indicated, and that the larvæ vary in color, the dark form (*b*) and white form (*c*) being shown.

BIOLOGIC NOTES.

On July 23 nearly mature larvæ of the first brood were fairly abundant on lamb's quarters along the fences and irrigation ditches. In some places it was noticed that they had spread from the weeds to sugar beets and had stripped the foliage from the first three or four rows nearest the fences. On August 3 and 4 full-grown larvæ were found in moderate numbers on sugar beets and lamb's quarters at Fort Collins and Greeley in northern Colorado, and on August 10

a large cluster of eggs of this species was taken on a sugar-beet leaf at Rocky Ford, Colo. August 13, at a seed farm east of Rocky Ford, many clusters of eggs, thousands of newly hatched larvæ, and some larvæ one-third grown were found on a large patch of rhubarb. A dozen or more moths were also observed on the rhubarb, some of which were depositing eggs. Rhubarb, possibly because it provided so much protection to the moths, was a favorite food plant and great numbers of eggs were deposited on it. The larvæ, after partially or completely stripping the large leaves, spread to other plants.

By August 24 larvæ, varying in size from quite small to one-half grown, were seen in many beet fields. Infestation was usually confined to spots, often only a corner of a field being infested.

By September 6 infestation had become general and there was probably not a field of beets in the Rocky Ford district in which larvæ were not present, at least in small numbers. At this date a large portion of the larvæ were over half grown. The worst infestation occurred within a radius of 2½ miles from the town. With few exceptions, the beets outside of this area were not seriously infested, and later examinations throughout the infested portions of the valley showed that the worst infestations were close to the towns, although in some cases the infestation extended miles beyond them.

September 11 the first cocoon was found, containing a larva which pupated a few days later. By September 14 many larvæ had matured, left the beets, and were seen hurrying away in search of places for pupation. September 17, several larvæ were found dead from a fungous disease. By September 20, although larvæ were still abundant and as many as 16 individuals were counted on a single beet, many had matured and crawled under heaps of weeds, grass, rubbish, boards, etc., along fences and irrigation ditches, and had formed cocoons. Of 20 cocoons which were examined at this time, 19 contained live larvæ and 1 a new, soft pupa. Seventeen of these larvæ pupated within the next three or four days. At this date, September 20, a large acreage of the beets had been badly defoliated. In some fields nothing remained of the foliage except a few young leaves (which the larvæ usually avoided), the petioles, and some of the larger veins of the older leaves.

September 22, in the corner of one beet field, over an area about three-fourths of an acre in extent, many larvæ were troubled with a fungous disease identified as *Botrytis bassiana* Bals. About 2 per cent of the larvæ had died from this cause. It was noted September 25, and later throughout the Rocky Ford district, that the disease had not spread and that diseased larvæ did not exist or were rare, except in this corner.

By September 27 larvæ were noticeably less abundant and many defoliated beets were putting out new tops. Before the Diacrisia

infestation became very bad a considerable amount of the older beet foliage had been killed by the "leaf-spot" disease (*Cercospora beticola* Sacc.) and the plants had put out a new stock of leaves. The Diacrisia attack, following the "leaf-spot" injury, made necessary still another crop of leaves before the beets could mature. By October 5 the bulk of the larvæ had entered winter quarters. The cocoons were common under weeds and many contained pupæ. On October 12 there were still a few belated larvæ on the beets.

Between October 14 and 24 a trip was made through the beet-growing sections of the Arkansas Valley. At Las Animas, Colo., about 30 miles east of Rocky Ford, the larvæ had been abundant and destructive. This place appeared to be the eastern limit of injury. Examinations and inquiries made at Lamar and Holly, Colo., and at Garden City, Kans., showed that the larvæ had not occurred in unusual numbers at those places. West and north in the Arkansas Valley the larvæ occurred in injurious numbers as far as the beets were grown, i. e., into the country around Pueblo and Sugar City, Colo.

As late as October 24 occasional larvæ still occurred on the beets at Rocky Ford, Colo. At this date 100 cocoons were collected from under boards and weeds and examined. Seventy-four contained live pupæ, 4 contained dead pupæ, in 10 were live larvæ, and in 12 dead larvæ. Two of the live larvæ had the eggs of a tachinid parasite fastened on their backs and one of the dead larvæ contained a live tachinid larva. The other larvæ had evidently died either from a fungous disease or from natural causes. Two of the dead pupæ were deformed and the other two had evidently died from disease. By October 30 the larvæ had almost completely disappeared from the beet foliage.

A remarkable feature of this outbreak is that the larvæ had so few natural enemies. Birds did not eat them, and with the exception of a few individuals which were killed by parasites and disease they appeared to be unmolested.

On November 12 thousands of healthy pupæ were in condition to pass the winter safely. If the pupæ are not killed by man or by adverse weather conditions, there is every indication that there will be another outbreak of the pest during 1910.

LIST OF PLANTS INJURED.

During September, when the larvæ occurred in most noticeable abundance, they were found feeding on the following plants: Sugar beet, stock beet, table beet, rhubarb, cabbage, cauliflower, turnip, radish, celery, carrot, parsnip, eggplant, potato, pumpkin, squash, watermelon, cantaloupe, sweet potato, corn, lima bean, string bean, asparagus, pea, peanut, alfalfa, hollyhock, morning-glory, canna,

hyacinth, dahlia, cherry, gooseberry, blackberry, raspberry, currant, grape, dock (Rumex), Amaranthus, Chenopodium, Helianthus, *Solanum rostratum*, Verbesina, Ambrosia, Russian thistle (*Salsola tragus* Auct.), and Spanish needle.

EXPERIMENTS WITH ARSENICALS.

Opportunity was afforded for testing arsenate of lead and Paris green as means of suppressing the yellow-bear caterpillar on sugar beets and celery.

Experiments were made as follows:

Experiment No. 1.—Arsenate of lead applied at the rate of 6 pounds in 100 gallons of water.

Experiment No. 2.—Arsenate of lead at the rate of 8 pounds in 100 gallons of water.

Experiment No. 3.—Arsenate of lead at the rate of 10 pounds in 100 gallons of water.

Experiment No. 4.—Arsenate of lead, 8 pounds to 100 gallons, applied twice to the same plants, practically equaling 16 pounds of the arsenate to 100 gallons of water.

In these experiments 150 gallons of the mixture at the various strengths were applied September 7–9, 1909, to 3 acres of sugar beets with an ordinary barrel sprayer, mounted on a cart and drawn by a mule. The sprayer was fitted with an 8-row attachment and nozzles of the Vermorel type, and the upper surface of the beet foliage was given an even coating of poison. Traces of the poison were visible on the sprayed foliage for nearly a month after application.

These four experiments were entirely unsuccessful, as practically no larvæ were killed either in the field or in cages supplied with poison-coated leaves. In both cases the poisoned foliage was eaten readily. A sample of the arsenate of lead used in the experiments was analyzed by the Bureau of Chemistry and found to be of unusually good quality.

Experiment No. 5.—Arsenate of lead (Disparene) at the rate of 8 pounds in 100 gallons of water.

September 21, 6 gallons were applied with a small compressed-air sprayer fitted with a nozzle of the Mistry type to 8 rows of celery, each about 90 yards in length. A very thorough and even coat of poison was given the plants, but very few larvæ were killed.

An analysis made of this arsenate of lead by the Bureau of Chemistry showed that it was of unusually good quality.

Experiment No. 6.—Paris green, 5 pounds, and lime, 5 pounds, to each 100 gallons of water.

September 25, 2 gallons of this mixture were applied with a compressed-air sprayer and nozzle of the Mistry type to 2 rows of celery, each about 90 yards in length. Twenty-four hours after the

treatment 15 per cent of the larvæ were dead, and within three or four days few larvæ remained on the plants. The disappearance of the larvæ was not entirely due to the Paris green, as the celery was sprayed, at about the same time the poison was applied, with a solution of lye-sulphur for the common red spider (*Tetranychus bimaculatus* Harv.). This solution was evidently very distasteful to the larvæ and they went over to the unsprayed or check plants.

Experiment No. 7.—Paris green, 8 pounds, and lime, 8 pounds, to 100 gallons of water.

September 1 about 40 gallons of this mixture were applied to 1 acre of sugar beets with the same equipment used in Experiments Nos. 1, 2, 3, and 4. Some trouble was experienced in keeping this mixture in suspension, but a fairly even coat of poison was made, which remained visible for at least ten days after the treatment.

This application was ineffective, for although a few partly grown larvæ were killed the number was so small that a week later the larvæ were as abundant on the sprayed plants as on those unsprayed. Analysis made of a sample of the Paris green used in this experiment showed it to be of good quality.

Experiment No. 8.—Paris green, 10 pounds, and lime, 10 pounds, in 100 gallons of water. On September 12, 6½ gallons of this mixture were applied with a compressed air sprayer and Mistry type nozzle to 5 rows of celery, each row being 100 yards in length. Although the mixture required frequent agitation to hold the poison in suspension, an even coat of poison was applied.

Twenty-four hours after the application 55 per cent of the larvæ were dead, and three days later but few living individuals could be found on the sprayed plants, while on the check row they were still abundant. This treatment was extremely effective, as practically 100 per cent of the larvæ were killed.

Experiment No. 9.—Paris green, 10 pounds, and lime, 10 pounds, to 100 gallons of water. On September 21, 9 gallons of this mixture were applied to 10 rows of celery, each row being about 90 yards in length. This experiment was a repetition of No. 8, and the results were practically the same.

Experiment No. 10.—Paris green, 10 pounds, and 10 pounds of lime to 100 gallons of water. On September 14 about 35 gallons of this mixture were applied to a little over half an acre of sugar beets. An ordinary barrel sprayer mounted on a handcart was used. The sprayer was fitted with an agitator so small that it was impossible to keep the poison in suspension. As a result the bulk of the poison was applied to the first few rows of beets sprayed. Owing to rain of the previous day the soil was so moist in the beet field that the pump could not be taken into it, and the mixture had to be applied through a 50-foot length of heavy garden hose and a nozzle of the Vermorel

type. The hose could not be handled to advantage, and an extremely poor and unsatisfactory application was made.

Where the coat of poison was thick, a good many of the larvæ were killed, but as the amount of poison diminished the number of dead larvæ diminished also and the experiment was considered a failure from every standpoint.

Shortly before any of the above experiments were undertaken, one of the beet growers made tests with Paris green at the rates of 1 pound and 2 pounds in 50 gallons of water against these larvæ on sugar beets. These tests were not made under the writer's direction, but from all appearances careful work was done. The poison did not kill a material number of the larvæ; and as these strengths were so obviously ineffective, the apparently excessive strengths were used in the experiments which were conducted later.

In none of the experiments with arsenate of lead was the foliage, either of sugar beets or celery, burned, but with Paris green, wherever the foliage was partly eaten there was some burning. This, however, was not serious in any case. Leaves remaining entire, even the very tender ones at the center of the plants, were uninjured.

The weather conditions were ideal during the time these experiments were made.

The results of these spraying experiments are summarized in the following table:

Results of experiments with sprays against the yellow-bear caterpillar (Diacrisia virginica) on sugar beets and celery.

Experiment number.	Date.	Insecticide used.	Larvæ killed.	Remarks.
	1909.			
1	Sept. 7	Arsenate of lead 6 pounds to 100 gallons of water.	Very few	Applied to sugar beets with barrel sprayer fitted with 8-row attachment.
2	do	Arsenate of lead 8 pounds to 100 gallons of water.	do	Applied to sugar beets with 8-row sprayer.
3	Sept. 9	Arsenate of lead 10 pounds to 100 gallons of water.	do	Do.
4	Sept. 7–8	Arsenate of lead 16 pounds to 100 gallons of water.	do	8 to 100 mixture applied twice to same plat of sugar beets with 8-row sprayer.
5	Sept. 21	Arsenate of lead 8 pounds to 100 gallons of water.	do	Applied with hand sprayer to celery.
6	Sept. 25	Paris green 5 pounds and lime 5 pounds to 100 gallons of water.	At least 15 per cent.	Applied to celery with hand sprayer. The larvæ deserted this plat because it was also sprayed with lye-sulphur solution for the common red spider.
7	Sept. 1	Paris green 8 pounds and lime 8 pounds to 100 gallons of water.	Very few	Applied with 8-row sprayer to sugar beets.
8	Sept. 12	Paris green 10 pounds and lime 10 pounds to 100 gallons of water.	Practically 100 per cent.	Applied with hand sprayer to celery.
9	Sept. 21	Paris green 10 pounds and lime 10 pounds to 100 gallons of water.	do	Applied with hand sprayer to celery. Repetition of experiment No. 8 to determine effect on older larvæ.
10	Sept. 14	Paris green 10 pounds and lime 10 pounds to 100 gallons of water.	Varying number	Applied to sugar beets. Results inconclusive because of poor application with faulty sprayer.

It will be seen that arsenate of lead, even when applied at an excessive strength by hand or machine sprayer, was entirely ineffective against the larvæ of *D. virginica* on sugar beets and celery. Paris green, when applied very thoroughly by hand to celery, gave perfect results when used at excessive strengths, but when applied to sugar beets with a machine sprayer (the only practical method with such a crop) it, too, proved ineffective.

The failure to kill the larvæ was not due to their being nearly mature, as in the earlier experiments they varied in size all the way from one-fourth to three-fourths grown; and as the development of this species is very irregular there were larvæ present which were not over half grown when all the experiments were made.

Judging from the results of these experiments, the arsenicals can not be depended on to control the larvæ of *D. virginica* on sugar beets. It is evident that clean cultural methods offer the best chance of keeping this species under control. The larvæ are very general feeders, and during the early growing season they evidently prefer weeds, such as lamb's-quarters, for food. Much benefit would be gained by keeping the ditch banks, and spaces along the fences, free from weeds.

On reaching maturity the larvæ crawl under heaps of dead weeds, tufts of grass, boards, and other rubbish, along the ditches and fences. In such quarters, which, especially in the case of weeds and grass, offer but slight protection, they construct frail cocoons in which the pupæ pass the winter. There is no better method of fighting this species than to burn the weeds, grass, etc., under which the pupæ find protection. This burning, which can be done any time between November 1 and April 1, would not only have the advantage of destroying quantities of weed seeds and Diacrisia pupæ, but would also kill the "alkali bugs" (*Monoxia* sp.?) which hibernate under the weeds in the same places as the Diacrisia pupæ.

In the field the larvæ were watched for over three weeks, or until a large proportion of them had matured and left the plants to pupate. The arsenate of lead was visible on the beet foliage during all of this time. A few larvæ were put in a cage supplied with the poison-coated leaves from the sprayed plats immediately after the application was made. These leaves were almost completely consumed during the following two days and after that unsprayed foliage was given them. Only one small larva out of about 25 died, although they were kept caged and under daily observation for ten days or until the oldest individuals began to prepare to pupate.

Personally the writer believes that the failure to kill the larvæ was due, in part at least, to the fact that an insufficient amount of spray was used to the acre. Fully 100 gallons to the acre should have been applied.

U. S. D. A., B. E. Bul. 82, Part VI. Issued December 8, 1910.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

NOTES ON THE CUCUMBER BEETLES.

By F. H. Chittenden,
In Charge of Truck Crop and Stored Product Insect Investigations.

INTRODUCTORY.

Among insects injurious to useful crops are many species of Diabrotica, most of which for convenience we may term cucumber beetles, the term including such species as feed upon cucurbits and similar plants. The commonest and best known examples are the striped cucumber beetle[a] (*Diabrotica vittata* Fab.), the twelve-spotted cucumber beetle or southern corn root-worm (*D. duodecimpunctata* Oliv.), and a western species related to the last, known as *Diabrotica soror* Lec. All of these are of the highest economic importance. The first mentioned is one of the most injurious species affecting truck crops; the second is very troublesome in the Southern States, while the last is about equally injurious in the Pacific region. In addition to these we now know of several other species which habitually or occasionally affect truck crops. In all there are a full score of species of this genus and two subspecies. A few of these are more often found on corn and grasses, hence will not be considered in this article.

The notes which follow are supplemented by a more detailed article, by Mr. H. O. Marsh, on the same and other species. The species which the writer will consider have never been treated at any length in a departmental publication, and the illustrations are here presented for the first time.

[a] The economic treatment of the first two species mentioned, the striped and the twelve-spotted cucumber beetles, is given in Circulars Nos. 31 and 59, respectively. In the latter, the western corn root-worm, which is more of a field-crop insect, is also treated. These publications may be obtained free of charge on application to the Secretary of Agriculture.

THE SADDLED CUCUMBER BEETLE.

(*Diabrotica connexa* Lec.)

What appears to be the first report of attack by the saddled cucumber beetle (*Diabrotica connexa* Lec.) was that made by Mr. C. S. Spooner, April 10, 1907, while engaged in truck crop insect investigations in this Bureau. It was found attacking cucurbitaceous plants at Corpus Christi, Tex. Mr. E. A. Schwarz, of this Bureau, however, states that he had met with it commonly in western Texas in earlier years, attacking cucurbits.

This species (fig. 19) belongs to the same series as *Diabrotica balteata* Lec., but to a group in which the antennæ have the third joint fully as long as the fourth and twice as long as the second. The elytra or wing-covers are dark ochraceous yellow with a purplish-brown transverse band at the base, another just forward of the middle, and with four roundish spots of the same color representing a third band. The first two bands are usually united on their outer edges, inclosing a more or less heart-shaped area of ochraceous yellow color. The head is colored about like the bands and spots on the elytra. This insect is a little larger than *D. balteata* and measures nearly three-tenths of an inch (7 mm.) in length.

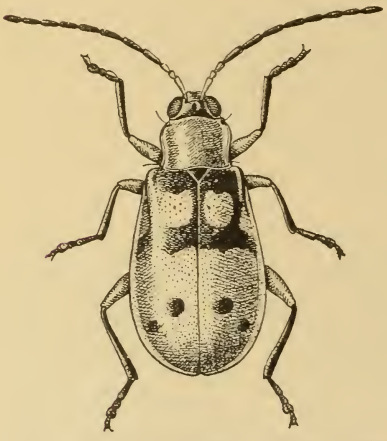


FIG. 19.—The saddled cucumber beetle (*Diabrotica connexa*): Beetle, about 5 times natural size. (Original.)

It is recorded by Horn,[a] who describes the adult in detail, from "Texas and Mexico." Jacoby[b] figures the species and mentions Tuxtla in Mexico.

THE PAINTED CUCUMBER BEETLE.

(*Diabrotica picticornis* Horn.)

October 13, 1905, Mr. F. C. Pratt observed the painted cucumber beetle (*Diabrotica picticornis* Horn) at San Antonio, Tex., in great numbers in the blossoms of okra and on beets, associated with *D. balteata*. The species was received December 12, 1906, from Mr. F. B. Headley, from San Antonio, Tex., with the report that it was eating vetch and horse beans. It was associated with *D. balteata* and *D. 12-punctata*. Mr. C. S. Spooner observed the same species on squash and on cotton at San Antonio, Tex., in June, 1907.

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[a] Trans. Amer. Ent. Soc., Vol. XX, p. 91, 1893.

[b] Biol. Centr.-Amer., Coleop., Phytophaga, Vol. VI, Pt. I, 1887, fig. 20, Pl. XXXII.

Following is a description of the egg:

The egg.—Opaque buff, the surface slightly or apparently pulverulent, finely sculptured, and ringed in many deep hexagonal pits as in other species of Diabrotica. The outline, however, is extremely irregular, and the size is similarly variable. Average length, 0.7 mm.; width, 0.5 mm.

The eggs were obtained in large numbers, deposited singly and distributed over the lower surface of cucumber leaves. The eggs under observation were deposited June 24 to July 3.

This species (fig. 20) belongs to the same series as *D. balteata* but to a group in which the antennæ have the second and third joints small, together rarely longer than the fourth. The elytra or wing-covers are ornamented about as in *D. connexa*, but with the four roundish posterior spots forming a crescent. The head and metathorax are black, as are the bands and spots on the elytra. The thorax varies from dark yellow to bright red. The beetle measures less than three-tenths of an inch (6.5 mm.) in length.

FIG. 20.—The painted cucumber beetle (*Diabrotica picticornis*): Beetle, about 6 times natural size. (Original.)

The distribution recorded extends only from Texas to Mexico. Horn (loc. cit.) wrote of the distribution, "Occurs in Texas, locality unknown."

THE BELTED CUCUMBER BEETLE.

(*Diabrotica balteata* Lec.)

What is probably the first record of injurious attack by the belted cucumber beetle (*Diabrotica balteata* Lec.), or, indeed, the first record of any food plant for it, was made in 1904 in an editorial note in Bulletin 44 of this Bureau (p. 84). Specimens of the beetle were received from Mr. A. L. Herrera, December 3, 1902, with the report that the species was injurious to wheat at Salvatierra, Guanajuato, Mexico.

The first report of injury in this country was made by Mr. F. C. Pratt, of this Bureau, October 5–7, 1905, while at Brownsville, Tex. Mr. Pratt observed the adults of this leaf-beetle in great numbers on beans, corn, and okra, especially in the blossoms, and on cucumbers. In this locality it practically displaced the two usually more common cucumber beetles, *D. 12-punctata* Oliv. and *D. vittata* Fab. In its work on beans it resembles the bean leaf-beetle (*Cerotoma trifurcata* Forst.). The same species was observed under the same

conditions at San Antonio, Tex., October 13, and at New Braunfels, Tex., October 27.

December 12, 1906, this species was received at the Bureau of Entomology from Mr. F. B. Headley, San Antonio, Tex., with the report that it was injuring vetches and horse beans. It was associated with *Diabrotica 12-punctata* and *D. picticornis*.

June 15, 1907, Mr. C. S. Spooner, while working under the writer's direction at San Antonio, Tex., found numerous beetles of this species on squash, where it was associated with *D. picticornis*. It was also noticed on cotton.

During 1908, Mr. D. K. McMillan, of this Bureau, observed this beetle during March on eggplant at Olmito, Tex., eating melon

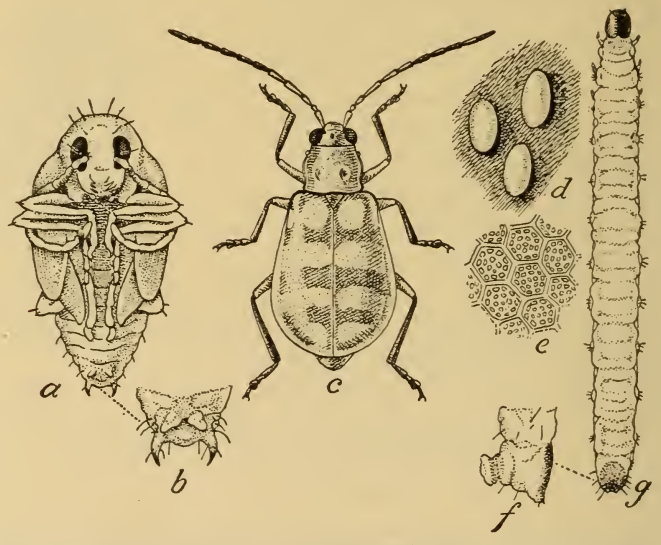

FIG. 21.—The belted cucumber beetle (*Diabrotica balteata*): *a*, Pupa; *b*, anal segment of same; *c*, beetle; *d*, eggs; *e*, much enlarged surface of same; *f*, anal segment of larva; *g*, larva, dorsal view. *c*, *g*, About 6 times natural size; *a*, *d*, a little more enlarged; *b*, *e*, still more enlarged. (Original.)

leaves at Brownsville, Tex., in May, and on beans and eggplant at Harlingen, Tex., in November, attacking the blooms.

The egg of this species may be described as follows:

The egg.—Pale yellowish buff, with the surface moderately shining, and with the usual hexagonal pits well defined but comparatively shallow. Form somewhat regular oval, corresponding rather closely to that of *Diabrotica vittata*. Length, 0.61 mm.; width, 0.35 mm.

The eggs were first obtained, July 1, in three masses deposited, in confinement, on the lower surface of cucumber leaves, the individual eggs being so closely applied to each other that they could hardly be separated without breaking them.

During 1910 Mr. M. M. High found this beetle attacking lettuce, cabbage, and onions at Brownsville, Tex. February 22 it was

observed feeding on onions on the farm of a Mr. Bass at Lyford, Tex. In some instances the adult was observed some distance toward the apex and on the inside of the leaf. A hole was made in the middle portion of the leaf just large enough for the insect to enter. In this way it conceals itself and feeds quietly from the inner side of the onion leaf.

This species, with the others here considered, belongs to what Horn has classified as Series A of the genus. Thus classified they are related to the common twelve-spotted cucumber beetle (*D. 12-punctata* Oliv.). The characters by which they are separated from Series B and C, which also include injurious forms, are as follows:

The elytra or wing-covers are irregularly, not closely punctate; the surface is without impressed striæ or sulci (channels); the tibiæ or shanks have a distinct carina or ridge extending the entire length of the outer edge. In this series *balteata* falls into a second group in which the second and third joints of the antennæ are small, together rarely longer than the fourth, usually shorter.

The beetle, illustrated by figure 21, *c*, is greenish yellow in well-preserved specimens, with red head, black metathorax, and elytra ornamented with three transverse green bands. Sometimes these bands have a bluish tint and frequently also are almost entirely lacking, the species showing great variation in this regard. The length is from one-fifth to one-fourth of an inch (5–6 mm.).

The distribution accorded by Horn is from Texas southward through Mexico to Colombia, South America, but that it can occasionally extend its range or is accidentally carried to other regions is proved by a specimen which the writer saw when it was collected at Rosslyn, Va.

THE WESTERN TWELVE-SPOTTED CUCUMBER BEETLE.

(*Diabrotica soror* Lec.)

RECENT INJURY.

The records of the Bureau of Entomology show considerable injury by the western twelve-spotted cucumber beetle (*Diabrotica soror* Lec.) in recent years, especially in 1907 and 1908. December 11, 1906, Mr. Frederick Maskew wrote that of the insects collected from the foliage of growing beets in and near Oxnard, Cal., this species was the most plentiful. It could be seen in myriads, copulating freely at that time. Injury sometimes attributed to wireworms was, he believed—judging from the description of the damage, its suddenness, and its short duration—probably the work of the larva of this species.

During 1907 complaint was received, March 3, from Mr. O. W. R. Treadway, Lodi, Cal., of injuries to melon, cucumber, squash, beans,

and corn; August 4, of injury to cucumber and melon, reported by Mr. S. Halverson, Gonzales, Cal.; August 7, of injury to cabbage, beans, and peas at Fort Ross, Cal., by Mr. J. B. Williams; August 11, by Prof. E. S. G. Titus of serious injury to melons at Imperial Junction, Cal., for that and the previous year. September 2, 1907, Mr. Williams again reported injury to vegetables at Fort Ross, Cal., cabbage being badly affected.

Of this species, Mr. I. J. Condit, of San Luis Obispo, Cal., wrote, on September 6, 1907, that it was the worst pest in that vicinity, swarming over everything and evidently having no choice as to its food. Gardeners there stated that they could not grow zinnas, daisies, and some other plants, as the flowers were so badly eaten that they were worthless. The blossoms were sprayed, which protected them, but the new buds opening the following day were attacked just as severely.

In 1908, Mr. H. O. Marsh, while carrying on investigations for the Bureau of Entomology at Tustin and Garden Grove, Cal., reported, September 24, injury by the larvæ to peanuts. At that time larvæ, pupæ, and newly formed adults were common in soil about growing peanuts, some of the larvæ being in the nuts which had been very badly injured by this species and a species of Blapstinus. Similar injury was noted by Mr. C. E. Ott at Garden Grove, Cal., who reported that the beetles caused him considerable trouble by nearly ruining a young orange grove earlier in the season.

March 16 of the same year, Mr. G. E. Beusel, Oxnard, Cal., sent specimens of this beetle, stating that it was attacking beet leaves. In one field the beetles had destroyed a very good stand of 30 acres of beets in a few days. Our correspondent took it for *Diabrotica 12-punctata*, whose larva he knew developed at the roots of grasses and corn. He also stated that he did not think that there was a practical remedy to check the work of the beetles of this insect on young beets.

April 16, Mr. Thomas J. Simpson, Noyo, Cal., wrote in regard to this insect and its work in gardens in that vicinity. In summer they were so thick that they ate leaves from beans, potatoes, corn, and other plants. A remedy was desired that would not poison the vegetables. Writing of this species April 24, Mr. Edward M. Ehrhorn, San Francisco, Cal., stated that in some seasons this beetle was quite a pest in orchards, especially on young trees, and that at times it also caused much damage to seed farms. The parasitic fly, *Celatoria diabroticæ* Shimer, in certain seasons keeps the beetle in check, appearing at these times in great numbers, probably on account of weather conditions.

As to remedies, he thought that an arsenical dusted on the plants would be preferable to an arsenical spray in treating this species in beet fields.

Mr. Marsh wrote further of this species and its occurrence at Tustin, Cal., that the peanuts were growing in sandy soil, and injury was everywhere apparent, but that larvæ and pupæ occurred September 28 only in spots in the heavier sandy soil. Here there were from one to twenty. Usually, however, there were from three to five to almost every plant, located from 2 to 3 inches below the surface. Most of the larvæ had matured. The pupæ were found in very fragile cells, and many of these were maturing, and there were many adults on the foliage and many soft, newly formed ones in the soil. The fact that the heavy soil is more moist and cooler than the lighter sand probably accounts for the later maturing of the beetles in such locations. Up to December 17, the species, according to Mr. Marsh, had not gone into hibernation, the adults being still moderately common on spinach, lettuce, mustard, and other plants. They were flying or crawling about quite actively during the warm part of the day, and appeared to prefer spinach as a food plant.

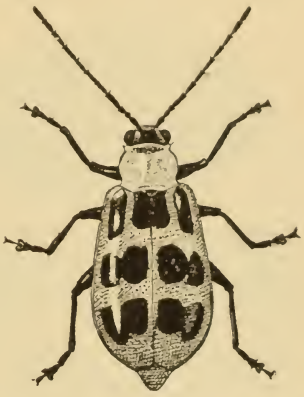

FIG. 22.—The western twelve-spotted cucumber beetle (*Diabrotica soror*): Female beetle, about 6 times natural size. (Original.)

DESCRIPTIVE.

The beetle of this species (fig. 22) differs from the common twelve-spotted cucumber beetle (*Diabrotica 12-punctata*) by having the entire lower surface black. In a good series of specimens at hand it is noticeable that even in preserved specimens the species under discussion preserves more of the natural green color than does the eastern species. The twelve spots are located and arranged about the same in the two species, but in *D. soror* there is a strong tendency to the union of at least one pair of spots on each elytron or wing cover. The pair of middle spots are most often confluent or united, and occasionally both the middle and the posterior spots unite. This is rare in the eastern species. In the latter, the lower surface, including a portion of the femora, is yellow. There is no great difference in size, but the eastern species will average a little larger. The antennæ are almost piceous, the basal three joints are slightly paler, and the thorax is less transverse. The length is about 6 millimeters.

This species occurs from Oregon, where it is common, southward through California to Arizona, and perhaps extends into Mexico.

The immature stages of this species have been described by Mr. R. W. Doane.[a]

[a] Journ. N. Y. Ent. Soc., Vol. V, pp. 15–17, 1897.

As nearly as can be made out without having fresh specimens of this species and the eastern form for comparison, there is only slight difference in the preparatory stages.

HABITS AND LIFE HISTORY.

According to the author quoted, this species is especially injurious to the interests of florists, the beetles eating unsightly holes in buds and petals of roses, chrysanthemums, and other ornamental flowers, feeding also on the leaves, there being an almost unrestricted range of food plants. Orchardists often suffer serious losses from the ravages of the beetles, which eat into young forming fruit and buds.

In Doane's experience, eggs (see fig. 23) were deposited from one-fourth to one-half an inch below the surface of the ground, near the base of the food plant, sometimes singly, but usually in numbers of between from twenty to fifty. Eggs in confinement hatched in about eighteen days (temperature not stated). Larvæ of various sizes were taken about the roots of different plants in March, April, and May, these observations being presumably made at Palo Alto, Cal. It was noticeable that the larvæ did not bore into the roots, as do our eastern species, but ate the roots from the outside, sometimes cutting young rootlets entirely in two. They were found in abundance feeding on the roots of sweet pea and alfalfa and sparingly on other plants. When the larva becomes full grown it approaches the surface of the ground and forms an oval or spherical cell, in which it remains ten or twelve days before transforming to the pupa. The pupal period lasted under observation from ten to fourteen days. Pupæ were first noticed early in April. The periods will vary with temperature, and there are indications of a second generation in southern California.

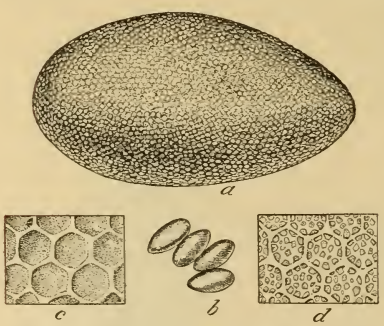

FIG. 23.—The western twelve-spotted cucumber beetle: *a*, Egg; *b*, small egg mass; *c*, *d*, sculpture of egg. *b*, Much enlarged; *a*, very greatly enlarged; *c*, *d*, highly magnified. (From Webster, unpublished.)

OTHER RECORDS OF INJURY.

In 1880 mention was made of injury by this species to the fruit of apricot in California.[a] Injury to garden plants was also noted. Mention was made of great destruction to fruits and vegetables in 1890 in California.[b] The following year Mr. Koebele reported injury to young corn by the larvæ at Alameda, Cal., often three to five larvæ being observed cutting off the roots of a single plant.[c] A series of

[a] Comstock: Ann. Rep. Comm. Agr. for 1879 (1880), p. 246.
[b] Koebele: Bul. 22, O. S., Div. Ent., U. S. Dept. Agr., p. 87, 1890.
[c] Insect Life, Vol. III, p. 468, 1891.

articles was published on this species from 1901 to 1902 by Mr. E. J. Wickson.[a] There are also in the Bureau unpublished accounts of injury to orange trees, the leaves of which are skeletonized.

Two natural enemies of this species have been observed; one, the tachina fly, *Celatoria diabroticæ* Shim., also described as *Celatoria crawii* by Mr. Coquillett in 1890.[b] The other is a spider, also observed by Mr. Coquillett, and known as *Xysticus gulosus* Keys.[c]

THE WESTERN STRIPED CUCUMBER BEETLE.

(*Diabrotica trivittata* Mann.)

The western striped cucumber beetle (*Diabrotica trivittata* Mann.), which is very closely related to the eastern striped cucumber beetle (*Diabrotica vittata* Fab.), is common throughout the State of California and extends into Oregon, where it practically replaces the eastern form, although, according to records, it is not nearly so injurious. We have indeed few records of injurious occurrences. Since 1898, however, when the writer recorded injuries by this species to cucurbits, there have been scattered reports of injuries to this class of plants, all of which it attacks. It attracts much more attention when it occurs on fruit trees, and has been accused of considerable injury to ripening peaches and apricots. Like the eastern form, also, it is found associated with a closely related species, in this case the western twelve-spotted cucumber beetle just considered. From the striped cucumber beetle of the East it may be separated chiefly by its darker colors. The antennæ are entirely piceous, the thorax bears two coalescing foveæ, and the legs, with the exception of the bases of the femora, are entirely black.

In 1903 we received report of injury by this species to various plants in the neighborhood of Dehesa, Cal., and in July, 1905, to beans, cucumber, squash, and the silk of corn in the vicinity of Salem, Oreg. In this latter locality it was associated with the common *Diabrotica soror* Lec. August 11, 1907, Prof. E. S. G. Titus stated that melons had been seriously injured for two years past in the vicinity of Imperial Junction, Cal. During that year and in succeeding years this species was found, by various agents, collaborators, and special correspondents who visited the sugar-beet region of the Pacific States, in sugar-beet fields, where, however, it was doing no serious injury.

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[a] Pacific Rural Press, June 30, 1900, et seq.

[b] Coquillett: Insect Life, Vol. II, p. 233, 1890.

[c] Loc. cit., p. 74, 1890.

BIOLOGIC NOTES ON SPECIES OF DIABROTICA IN SOUTHERN TEXAS.

By H. O. Marsh,
Agent and Expert.

INTRODUCTION.

During the first half of the year 1909, while engaged in an investigation of insects injurious to truck crops, an opportunity was presented to make a study of the species of leaf-beetles of the genus Diabrotica occurring at Brownsville, Tex., and vicinity.

In the present paper the species considered are *Diabrotica balteata*, *D. picticornis*, *D. vittata*, and *D. 12-punctata*. The first two species are rather more abundant in Texas than elsewhere in the United States, this being especially true of the second. The other species have a more general distribution.

I am under obligations to Mr. D. K. McMillan for the descriptions of the early stages of *D. balteata* and to the late Dr. C. F. Wheeler, of the Bureau of Plant Industry, for identification of the food plants mentioned in the text.

OBSERVATIONS ON DIABROTICA PICTICORNIS Horn.

The painted cucumber beetle (*Diabrotica picticornis* Horn) was extremely rare in southern Texas during the season of 1909, and only occasional specimens were observed, although during May and June, 1908, Mr. McMillan noted them in abundance at Brownsville, Tex., eating the blossoms and foliage of cucurbits, especially that of Hubbard squash.

During 1909 the first specimen, a female, was taken March 1 on a Verbesina blossom. March 15 a female was taken feeding on cucumber foliage and continued in captivity until May 22, but she deposited no eggs. April 15, a half dozen individuals were observed on cymlings. The females appeared to be well filled with eggs. Of two which were placed in confinement at that date, one was still living June 14, but neither deposited eggs.

OBSERVATIONS ON DIABROTICA BALTEATA Lec.

The belted cucumber beetle (*Diabrotica balteata* Lec.) is active during the entire year in southern Texas, and is by far the most injurious and common Diabrotica in the lower Rio Grande valley. It is almost omnivorous and injuries caused by it are thus widely distributed and

less noticeable than they would be if the species were a more dainty feeder. The truck growers in the valley view this species as an unavoidable evil and make little effort to combat it. They have no distinctive name for it, and it is not unusual to hear it mentioned as "spotted green-bug," "tomato bug," "pumpkin bug," or "ladybug."

FOOD PLANTS.

This beetle is primarily a truck crop pest and has been observed actually feeding on string beans, lima beans, English broad beans, tomatoes, potatoes, eggplant, pepper, turnip, peas, peanuts, squash, cantaloupe, cucumber, watermelon, pumpkin, okra, spinach, beets, lettuce, asparagus, and sweet corn. Among field crops attacked are corn, sorghum, alfalfa, cotton, cowpea, soy bean, and vetch, and *Desmodium tortuosum*. There is one recorded instance of its injuring tender fig and orange leaves and it was found feeding on the foliage of *Sesbania aculeata* and *Cajanus indicus* and on the blossoms of *Dolichos atropurpureus*. A favorite wild food plant is *Verbesina encelioides*. The beetles gather in great numbers on exposed tubers of *Ibervillea lindheimeri* and more rarely feed on *Amaranthus retroflexus* and *A. spinosus*. They also feed on the blossoms and foliage of *Solanum elæagnifolium* and Helianthus.

CHARACTER OF INJURY.

Among the truck crops mentioned beans of several varieties are often seriously injured, many blossoms being destroyed, and sometimes young and tender plants are entirely killed. With eggplant, tomatoes, and cucurbits, not only are the foliage and blossoms attacked, but the unopened blossom buds are eaten into and thus many incipient fruits are destroyed. Injury is particularly severe with eggplant, where many blossoms are ruined. The silk and unripe kernels, as well as foliage, of corn are eaten and the young corn plants are often badly riddled.

The larvæ were found feeding on corn, sorghum, and string beans. In the case of corn and sorghum they feed on the larger roots and bore into the crown, while with beans they scrape the main stalk below the surface of the soil. Injury by the larvæ did not seem serious with any plants on which they were found.

RECORDS OF OCCURRENCE.

During the middle of January, 1909, a freeze occurred in the lower Rio Grande valley which killed practically all tender vegetation, except in sheltered spots. On January 25 a good-sized patch of *Verbesina encelioides* that had escaped freezing was thickly infested with the adults, which were feeding eagerly.

About twenty nearly mature larvæ were found February 5 feeding at the roots of sorghum at Harlingen, Tex. These were placed in

a rearing jar and one made its cell February 11, pupated on February 16, and the adult developed February 27. Adults continued to issue until March 5.

The beetles were abundant at Brownsville, Tex., February 6, on string beans which they nearly defoliated. February 11, a half-grown larva was found feeding at the base of a string bean plant.

Adults were observed feeding on tender fig leaves at Santa Maria, Tex., February 24.

March 5 about twenty eggs were found at the base of string bean plants. The female beetles had evidently gone down in cracks in the earth as far as possible and oviposited in the loose soil from 1 inch to 2½ inches below the surface and from ½ inch to 2 inches from the plant. The eggs were placed singly as a rule, but a few were in clusters of from two to five. No larvæ were observed at this date. The beetles were fairly common and some pairs were mating.

Eggs were found about young sweet corn March 15, placed in the loose soil at the base of the plants, singly and in clusters of four or five. Twenty eggs were found about one small plant.

The beetles were reported seriously injuring young pepper and okra at Mercedes, Tex., April 15.

They were numerous on lima beans a week later, attacking chiefly the large first leaves and cutting large holes in them. It appears that they return repeatedly to the same leaf and eat a large area at one place. April 26 a nearly mature larva was found feeding on the roots of sweet corn.

During May the beetles were present in moderate numbers. On the 10th some were observed feeding on buds of tomato and on squash foliage. Females, with abdomens distended with eggs, were present, and one or two of these which were placed in confinement deposited eggs on the 12th.

May 27 the adults were fairly common on alfalfa, cotton, tomatoes, and English broad beans.

NOTES ON LIFE HISTORY.

Beginning with March 1 an effort was made to work out the life history of this species. The record for a generation at this time follows:

Life-history record of a single adult female of Diabrotica balteata confined March 1, 1909.

March 1	Female confined in rearing jar.
March 3	37 eggs deposited.
March 12	37 eggs hatched.
April 1	First larvæ made cells.
April 7	First larvæ pupated.
April 18	First adults developed.
April 20	First adults issued from cells.
April 21	Last of adults issued, of which 24 developed.

From the above record the stages are as follows:

	Days.
Egg stage	9
Larval stage	26
Pupal stage	11
Total	46

The mature larvæ remained quiescent in the cells for 6 days before pupating, and the beetles were in the cells from 2 to 3 days before issuing. The adults begin to feed as soon as they leave the cells, although they are still soft and light colored for from 3 to 5 days. No pupæ were found in nature, but in the rearing jars the larvæ, when mature, burrowed into the soil from ½ inch to 2 or 3 inches and formed cells by wriggling about. The larvæ and pupæ were very tender and were easily killed if handled at all roughly or if the soil in the cages became dry. A moderately moist condition appeared to be most favorable.

Three females, which were placed in confinement during the first days of March, deposited respectively during one day as follows; 23, 45, and 48 eggs. The incubation period of these eggs varied from 9 to 11 days. One of these lots was carried through with the following results:

	Days.
Egg stage	9
Larval stage	25
Pupal stage	11
Total	45

On April 21, 8 adults which issued in the rearing jars between April 18 and April 21 were put together into one cage, with foliage of Verbesina, to breed.

Record of 8 adults of Diabrotica balteata which had issued in rearing jars April 18 to 21, 1909, and confined, April 21, in one cage with foliage of Verbesina, to breed.

1909.	Mated.	Eggs deposited.	Died.	Escaped.
April 24	0	0	1	.....
April 28	0	0	1	1
April 30	2	0	(a)	.....
May 14	0	0	1	.....
May 18	0	0	2	.....
Total ..	2	0	5	1

a Taken out; see table following.

None of the beetles deposited any eggs, nor were they observed mating.

The record for the pair which mated April 30 is as follows:

Record of egg deposition of a single female of Diabrotica balteata, which mated April 30, 1909.[a]

1909.	Number of eggs.
May 8	39
May 19	6
May 21	23
May 24	14
May 26	16
Total	98

[a] May 31, male died; June 2, female died.

This gives a total of 98 eggs from one female. The life of the male was 43 days and that of the female 45 days.

The record for the 39 eggs deposited May 8 is as follows:

Detailed record for the 39 eggs of Diabrotica balteata deposited May 8, 1909.

May 8	39 eggs deposited.
May 13	39 eggs hatched.
May 23	First larvæ made cells.
May 27	First larvæ pupated.
June 1	First adults developed.
June 2	First adults issued from cells.
June 4	All adults had issued.

The stages were:

	Days.
Egg stage	5
Larval stage	14
Pupal stage	5
Total	24

The larvæ of this species were confined in large jelly glasses and in large vials and fed with sections of sorghum cane. Of the three species reared (*Diabrotica balteata*, *D. vittata*, and *D. 12-punctata*), *Diabrotica balteata* was by far the most hardy, and this probably accounts for its abundance as compared with *D. vittata* and *D. 12-punctata*.

Records showed that one lot matured March 1, a second April 18, and a third June 1. Mr. McMillan found the beetles in greatest abundance during November and December. Judging from this and from the rearing records, there may be at least six generations, and probably one or two more each year.

Occasional mutilated beetles were found lying on cucurbit and other leaves and had evidently been killed by some predaceous insects. Many specimens dissected during May showed no internal parasites.

The temperatures at Brownsville during January, February, and March ranged from a minimum of 29° F. to a maximum of 95.1° F.

The extreme minimum of 29 degrees occurred only on one or two days during "northers," and excepting those few days the minimum did not get below 40 degrees. During April and May the range was from a minimum of 46° F. to a maximum of 95.5° F. The average temperature during these five months was as follows:

Average temperatures at Brownsville, Tex., from January to May, 1909.

1909.	Average maximum.	Average minimum.
	° F.	° F.
January	75.3	56.1
February	75.7	55.0
March	81.7	60.0
April	82.5	65.2
May	85.0	70.5

The following description of the earlier stages was prepared by Mr. McMillan from living material:

DESCRIPTION.

Egg.—Pale yellow, oval and regularly elliptical, very finely sculptured, about 0.6 mm. long by 0.33 mm. wide.

Newly hatched larva.—Pale yellow, head light brownish, anal segment light gray. Slender, with head and thoracic segments broader than rest of body, except anal segment, which is covered by a shield flattened and rounded at posterior margin. Body sparsely covered with short, colorless hairs which in length are about one-half diameter of body. Length, 2.25 mm.; width, 0.25 mm.

Mature larva.—Light yellow, head and anal plate light brownish. Body slender, dorsal and ventral surfaces smooth, longitudinal wrinkles provided with scattered hairs on lateral surfaces. A few short hairs on head and anal segment. Head slightly longer than wide, flattened. Length, when extended, 12 mm.; width, 1.25 mm.

Pupa.—Light yellow, concolorous. Body rather long, oval in general outline, abdomen tapering slightly. A few scattered hairs on head and abdomen. A pair of stout spines on dorsal surface of anal segment and a pair of fleshy tubercles on ventral surface of same. Length, 5 mm.; width, 2.5 mm. [D. K. McMillan].

EXPERIMENTS WITH REMEDIES.

Arsenate of lead appears to be an excellent remedy for this pest, as is shown by the following records:

During November, 1908, Mr. McMillan sprayed one-tenth of an acre of tomatoes, which were being damaged by this Diabrotica, with arsenate of lead at the rate of 6 pounds to 100 gallons of water, and with pyrox, a commercial brand of combined arsenate of lead and Bordeaux mixture, at the rate of 8 pounds to 100 gallons. The results from both insecticides were very good, no differences being noted between them.

February 8, 1909, a patch, about one-twentieth of an acre in extent, of tender-leaved string beans was being rapidly defoliated by this species at Brownsville, Tex. With the exception of two

check rows, the entire patch was sprayed by the writer with arsenate of lead at the rate of 10 pounds to 100 gallons of water. This rather excessive strength of arsenate was used in order to determine its effect on the foliage, which was very tender. At the time of spraying the beetles were in great abundance, from one to six individuals being present on every plant. The results of this treatment were checked up February 11. At that date the sprayed plants were almost entirely free from beetles, only an occasional specimen being seen on the under side of the leaves. The defoliation of the plant was almost completely checked, and there was no burning from the arsenate. The plants in the check rows were almost completely defoliated. The beetles, however, were not nearly so numerous as they were on February 8 when the other plants were sprayed. This decrease in numbers was probably due to the fact that many beetles were killed by eating the poisoned plants in the adjoining rows. Unfortunately, a few days later the entire patch of beans was destroyed by a "norther" and no further observations could be made.

On March 20 this species, in company with *Diabrotica vittata*, was injuring young cucurbits at Brownsville. Mr. H. H. Jobson had these plants sprayed with a combination of Bordeaux mixture and arsenate of lead (6 pounds arsenate of lead to 100 gallons of Bordeaux mixture) and later he reported good results from the treatment.

OBSERVATIONS ON DIABROTICA VITTATA Fab.

Next in order of importance, from an economic standpoint, is the striped cucumber beetle (*Diabrotica vittata* Fab.). This species is usually rare in southern Texas as compared with *D. balteata* and its injuries are confined to cucurbits.

The first occurrence of this species in southern Texas recorded is for January 26, when adults were found in squash blossoms at Brownsville. Occasional adults were observed during February, and on March 6 complaint was received from a grower near Brownsville, where the beetles were injuring cucumbers and melons, from one to five beetles being present on many plants. At this date, also, a similar report was received from Mercedes, Tex.

Mr. A. M. White, of Mercedes, later reported that he completely controlled this species, which was seriously injuring cucurbits, by spraying three times with arsenate of lead at the rate of 6 pounds in 100 gallons of water.

The beetles were causing noticeable injury to cucurbits at Brownsville March 20. The plants were sprayed, under the direction of Mr. H. H. Jobson, with a combination of 6 pounds arsenate of lead and 100 gallons Bordeaux mixture with successful results.

April 13, the writer found larvæ in numbers infesting squash plants at McAllen, Tex. Some plants were wilting and many of the roots

were found to have been scraped nearly bare, and in a few cases the larvæ had buried themselves in the main root. All observed were nearly mature. One larva made a cell April 17, pupated April 21, and the adult developed April 28. Other beetles developed April 30 and May 1.

During May beetles were observed, but no injury was noticed or reported.

June 10 the beetles were abundant at McAllen, Tex., feeding on the foliage and rinds of watermelons and disfiguring some of the melons. The foliage in some places was badly riddled, but the crop was so far advanced that this caused little damage. Many beetles hid during the middle of the day among cabbage and Amaranthus leaves for protection from the sun.

The life history of one generation of this species was worked out as follows:

Record of a single female of Diabrotica vittata placed in confinement April 26, 1909.

April 26	Placed in confinement.
May 2	42 eggs deposited.
May 10	42 eggs hatched.
May 21	First larvæ made cells.
May 24	First larvæ pupated.
May 29	First adults developed.
May 30	First adults issued.
June 2	All adults had issued.

The stages were as follows:

	Days.
Egg stage	8
Larval stage	14
Pupal stage	5
Total	27

The mature larvæ were in the cells three days before pupating and the adults remained in the cells from one to four days before issuing. The first pair of these beetles mated June 4, and the first eggs, 20 in number, were deposited June 11.

On May 3 another female deposited 58 eggs and the following record was obtained:

	Days.
Egg stage	7
Larval stage	15
Pupal stage	5
Total	27

During the first weeks of May, when this species was being reared, there was a period of excessive humidity. The larvæ were supplied with sections of cucumber vine as food. The humidity caused this food to decay very rapidly and this necessitated frequent renewal, and as a result many larvæ died and only a relatively small proportion was carried to maturity. The temperature during May, 1909,

as recorded at the local weather station, ranged from a minimum of 60.9° F. to 94.4° F.

Observation has not been carried far enough to enable the writer to state positively the number of generations in this region.

OBSERVATIONS ON DIABROTICA DUODECIMPUNCTATA Oliv.

The twelve-spotted cucumber beetle (*Diabrotica duodecimpunctata* Oliv.) occurs only in small numbers in southern Texas, and no complaints of injury were received concerning it.

On February 5 four mature larvæ were found feeding on the roots of sorghum at Harlingen, Tex. February 7 one of these made its cell; on the 15th it pupated, and on the 25th the adult developed. The other beetles developed a day or two later.

On May 12 a female with greatly distended abdomen was placed in confinement and deposited eggs as follows:

Record of egg deposition of a single female beetle of Diabrotica duodecimpunctata in confinement May 12, 1909.

1909.	Number of eggs.	1909.	Number of eggs.
May 14	68	May 29	38
May 16	75	June 1	19
May 19	63	June 6	20
May 24	67	June 8	(a)
May 26	55		
May 27	110	Total	515

[a] Beetle died.

This gives a grand total of 515 eggs from one beetle.

The record for the eggs which were deposited May 14 is as follows:

Detailed record for the 68 eggs of Diabrotica duodecimpunctata deposited May 14, 1909.

May 14	68 eggs deposited.
May 20	68 eggs hatched.
May 31	First larvæ made cells.
June 4	First larvæ pupated.
June 10	First adults developed.
June 12	First adults issued from cells.
June 14	All adults had issued.

The stages were as follows:

	Days.
Egg stage	6
Larval stage	15
Pupal stage	6
Total	27

This species proved very hard to rear and only a small proportion of the larvæ reached the pupal stage. The larvæ were placed in large jelly glasses and fed on sorghum cane.

U. S. D. A., B. E. Bul. 82, Part VII. Issued February 18, 1911

SOME INSECTS INJURIOUS TO TRUCK CROPS.

NOTES ON VARIOUS TRUCK-CROP INSECTS.

By F. H. Chittenden, Sc. D.

In Charge of Truck Crop and Stored Product Insect Investigations.

ON THE NATURAL ENEMIES OF THE COLORADO POTATO BEETLE.

SOME INSECT ENEMIES OF THE POTATO BEETLE.

Few, if any, noxious insects have so many recorded natural enemies as the Colorado potato beetle (*Leptinotarsa decemlineata* Say). A list of these has been recently compiled by the writer.[a] A few species not previously recorded have since been reported by special correspondents and agents of this office, and these will be mentioned here.

Pterostichus lucublandus Say.

July 3, 1908, Mr. J. Byron Roney, Plainville, Mass., sent specimens of the ground beetle *Pterostichus lucublandus* Say and reported that it was found on that date busily engaged in devouring the grubs of the Colorado potato beetle. Although this is an extremely common insect, one of the best known of the Carabidæ, it has not heretofore, to the writer's knowledge, been recorded as an enemy of the potato beetle.

Apateticus (Podisus) marginiventris Say.

Apateticus (*Podisus*) *marginiventris* Say, which closely resembles the spined soldier-bug (*P. maculiventris* Say), a well-known enemy of the Colorado potato beetle and other injurious insects, was observed attacking the larvæ of this potato beetle by Mr. H. O. Marsh, Chester, N. J., in August, 1908.

Perilloides (Perillus) bioculatus Fab.

Perilloides (*Perillus*) *bioculatus* Fab., a pentatomid bug, as is the preceding species, was reported by Mr. D. H. Shannon, Appleton, Wis., as having been noted killing the Colorado potato beetle in August, 1908. Two bugs were noticed attacking a mature beetle. They held it by the head and refused to relinquish their prey when the beetle was pulled off from the potato stalk on which it was feeding.

[a] Cir. 87, Bur. Ent., U. S. Dept. Agr., pp. 10–12, June 3, 1907.

Euthyrhynchus floridanus L.

July 7, 1909, Mr. Fred. A. Eigenman, Abbeville, S. C., sent specimens of *Euthyrhynchus floridanus* L., which he had found that morning on eggplant. When discovered the insect was attacking the larva of the Colorado potato beetle. As this was a new observation to Mr. Eigenman, he promptly apprised this office of the fact. This species is not uncommon in the Southern States, and specimens have been frequently received for determination, with notes on habits, from South Carolina, Florida, and Georgia.

It is highly probable that the species is beneficial, although there is a possibility that it may feed also on plant juices exceptionally, as is known to be the case with some related forms.

In looking over the files of the Bureau it is found that this species was reported from Lanford, Laurens County, S. C., June 24, 1887, by Mr. Y. N. Lanford, who stated that he found the insect to be a bee destroyer. While sweeping off webs and other refuse from a bee bench and "gums" (colloquial for box hives), he noticed one of these bugs with its beak inserted into the abdomen of a honey bee, just above the sting. He did not know, however, to what extent the insect attacks the bees.[a] During 1901 Mr. H. Walter McWilliams, Griffin, Ga., sent specimens with a letter dated October 28, stating that the species occurred in some numbers on catnip.

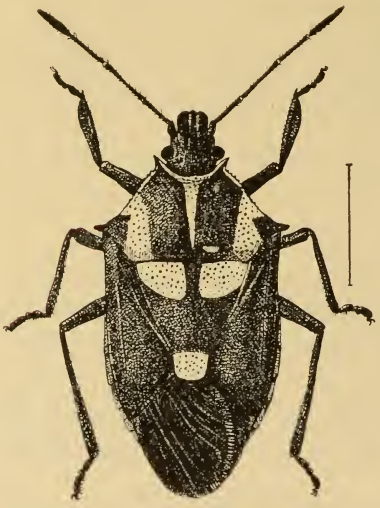

Fig. 24.—*Euthyrhynchus floridanus*, an enemy of the Colorado potato beetle. Enlarged. (Original.)

During 1907–8 Mr. H. M. Russell observed this bug attacking the green plant-bug (*Nezara hilaris* Say) on eggplant at Dade City, Fla., and the black walnut caterpillar (*Datana integerrima* G. and R.) on pecan at Orlando, Fla.

This species is a tropical form and is recorded as occurring also at New Orleans, La., in Mexico, and Central America generally, as well as in Venezuela, Colombia, and Brazil. A full bibliography was furnished in 1880 by W. L. Distant.[b] It has many synonyms, which is to be accounted for by its wide distribution and variability. The mature bug measures between one-half and three-fourths of an inch in length. The usual color is green above, spotted with red, the spots being arranged more or less as shown in the accompanying illustration (fig. 24). Individuals occur also without red markings,

[a] Mention of this bug attacking the honey bee is given in Insect Life, Vol. I, p. 88, Sept., 1888.

[b] Biologia Centrali-Americana, Hemiptera-Heteroptera, Vol. I, pp. 41–42, Oct., 1880.

some bear a single spot at the apex of the scutellum, while a common form has one apical and two basal scutellar red spots. A large portion of the lower surface is reddish yellow. The rostrum or beak is about half the length of the entire body.

Mr. Thomas Belt, in his publication[a] referring to this bug as *Pentatoma punicea*, states that on two occasions he found it sucking the juices from dead individuals of a "bright green rose chafer." Since the beetle was twice the size and weight of the bug, very active and taking wing quickly, he concluded, quite correctly, that "the only way in which the latter could have been overcome was by the bug creeping up and quietly introducing the point of its sharp proboscis between the rings of its body when the beetle was sleeping, and injecting some stupefying poison." In both instances the bug was on a leaf of a shrub with the bulky beetle hanging over suspended on the bug's proboscis.

SOME WILD BIRD ENEMIES OF THE POTATO BEETLE.

As the list of wild birds known to feed on the Colorado potato beetle furnished in Circular No. 87 is not quite complete, the following note from a list compiled by Mr. W. L. McAtee, and published in 1908, is of interest.

Speaking of the food habits of the grosbeaks, Mr. McAtee says:[b] "It should be noted also that several other birds, including the bobwhite, prairie chicken, sharp-tailed and ruffed grouse, red-tailed hawk, nighthawk, cuckoo, crow, English sparrow, cardinal, scarlet tanager, wood, hermit, and olive-backed thrushes, and robin, eat potato beetles occasionally."

June 20, 1910, Mr. B. A. Reynolds, of this Bureau, noticed a bird, which he identifies as the chipping sparrow, apparently capturing larvæ of the Colorado potato beetle on potato plants in his garden at East Riverdale, Md. When observed it was flitting or hopping along the ground, attacking the "slugs" from the stalk of the potato plants, taking as many as four or five from one plant and then proceeding to the next in the row. Later the bird crossed at different times to other parallel rows, repeating the operation. No other bird common in this vicinity is known to have this habit of running from row to row in garden patches as described, and although this bird is becoming common, as it was at the time of the introduction of the English sparrow, it has not been reported, to the writer's knowledge, as attacking the Colorado potato beetle in any form.[c]

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[a] The Naturalist in Nicaragua, ed. 2, rev., 1888, p. 127.

[b] Bul. 32, Bur. Biol. Surv., U. S. Dept. of Agr., p. 47, 1908.

[c] Mr. Reynolds also reported that Mr. B. C. Wheeler of the same place had a white rock pullet, an incubator chick, which developed the habit of feeding on this "slug."

GUINEA FOWLS AS DESTROYERS OF THE POTATO BEETLE.

The efficiency of the guinea fowl in destroying the Colorado potato beetle does not appear to have received much mention in available literature. Two special correspondents of this office have written the writer on this topic, one of them recently, and their experience is well worth publishing.

June 1, 1907, Mr. F. W. Speegle, Bremen, Cullman County, Ala., wrote that about 25 years ago the potato "bugs" made their appearance in his county and increased until they were so numerous that it was a hard fight to raise potatoes at all. Having learned that the guinea fowl would eat the beetles, he at once began to raise the fowls. In the spring of 1905, when the beetles appeared, the guineas were induced to enter the potato patch by strewing corn about the vines. After eating the corn the fowls consumed the beetles, apparently with great relish, and less than a week later not a "bug" could be found on the potato tops. A good crop was made, which was also clean of scab. He had the same experience in 1906, and since then had not seen a potato beetle in his potato fields and only a few on his entire farm. A few occurred out of the range of his guineas on what he terms "tread-soft" (probably a Solanum), which seems to be the principal diet of the bugs, excepting the potato. His neighbors who had no guinea fowls had as much trouble with the potato beetles as he did before he obtained the guineas.

Writing on the same topic Dr. George Vanden, Gallipolis, Ohio, stated in a letter received May 1, 1909, that many years ago when the Colorado potato beetle was very bad and when he and his neighbors had potatoes in adjoining patches, the neighbors "bugged" faithfully, but the bugs "multiplied and replenished," and the patch was very ragged, while his own vines were fine and flourishing, although no remedies had been applied. He soon found that the good condition of his own vines was due to his flock of between 20 and 30 full-grown guinea fowls that patrolled the patch and converted the "bugs" from a nuisance into "good guinea feed." He expressed himself as believing that this combination of raising potatoes and guinea fowls would not only be feasible, but to the mutual advantage of the potatoes and the guineas; at least it worked satisfactorily in his case.

It is to be hoped that correspondents who are troubled with potato beetles will make tests of the efficiency of the guinea fowl as a destroyer of this and other garden pests.

NOTES ON THE POTATO STALK WEEVIL.

Since the publication of a comprehensive article on the potato stalk weevil (*Trichobaris trinotata* Say) in 1902 [a] a few data have

[a] Bul. 33, Bur. Ent. U. S. Dept. Agr., pp. 9–18, 1902.

accumulated in regard to the habits of this insect which are worthy of record.

During 1907 Mr. F. D. Hopkins, while engaged in the Bureau of Plant Industry, collected some infested stems of cultivated Physalis of an unknown species, supposed to be a hybrid, grown at the Arlington Experimental Farm, at Rosslyn, Va. The stems submitted to the writer, October 30, contained at that late date one larva and three pupæ. Mr. Hopkins had noticed for some time a peculiar injury—the breaking of many stalks fully three-fourths of an inch thick—and attributed it, with good reason, to the inroads of the larva of this weevil. The complete rupture of the stalks was brought about by severe winds which were encountered on three different days in October. This is apparently the first record of injury by this species in the vicinity of the District of Columbia. It also shows that the insect can be much later in maturing than is generally supposed, the larvæ and pupæ being found much later than is usual. The first adult from this lot did not develop until November 25. The pupæ obtained wintered over as such but died during a very severe and unseasonable hot spell, when the insectary was not properly screened, in the latter days of March. Normally, they would not have developed for a month or two later. It has been quite generally stated by all writers on this species, as has been said in the article quoted, that all beetles mature by September and that hibernation is therefore always as a beetle, the knowledge of this fact being of great value in the control of the species.

During July, 1908, Hon. John H. Rothermel wrote of injury by this species in the vicinity of Reading, Pa., stating that it was eating into potato stalks and killing them. The same month Mr. Walter W. Jacobs complained that the potato crop in Delaware County, Pa., was infested with this species, which he accurately described working in the center of the stalk, eating its way from the roots upward.

In an earlier year Mr. F. C. Pratt observed this species attacking eggplant at Four-Mile Run, Virginia, about 30 per cent of a field being found injured by July 29. His notes are as follows:

> The larva was found in one plant examined and plants averaging 2 feet high were affected, some bearing fruit. After they were attacked the plants withered away and died. The owner of the truck farm stated that for three years his eggplant had died in the same manner and he had attributed the loss to the soil, the plants being grown at that time on low ground thought to be "sour." Each year he changed the location, but the same conditions had prevailed.

A cocoon of a parasite was observed at that time in the burrows of the insect in eggplant and later the chalcidid parasite *Eurytoma tylodermatis* Ashm. was reared from stems of *Solanum carolinense* infested by this species and collected by the writer in the District of Columbia.

MAGGOTS AFFECTING YAMS IN THE SOUTH.

Comparatively little attention has been paid to the insect enemies of sweet potato and yams in America. An exception is the sweet-potato borer or weevil (*Cylas formicarius* Fab.) which has been ably treated by Mr. A. F. Conradi in a recent publication [a] of the Texas Agricultural Experiment Station. Short accounts of other species, including the tortoise beetles, have been prepared by Riley, Sanderson, and others. The species which will be mentioned in the present article are apparently new as sweet potato pests.

March 11, 1908, Mr. P. J. Wester sent from Nassau, British West Indies, a yam, *Dioscorea alata*, badly affected with maggots. When received, owing to the long journey, leading to the destruction of many specimens, comparatively few larvæ remained. An examination showed that these were of three species, all pale yellow at the time of receipt. Some pupæ were also present. The specimens reared were identified by Mr. D. W. Coquillett and are as follows:

Lonchæa longicornis Will.—The flies of this species issued from March 13 to April 10. This is an ortalid and bears some resemblance to the better known *L. polita* Say. The head is dark brown, the thorax dark blue, and the wings are only slightly iridescent. In *polita* the head is a lighter brown, the thorax more distinctly blue, and the wings more strongly iridescent.

Euxesta nitidiventris Loew.—The adults issued from March 31 to April 3. This species is of about the same size as the preceding and resembles our commoner *E. notata* Wied. Superficially it differs by being duller colored, the thorax being feebly metallic blue and the wings not so strongly marked with black on the margin. This species has been reared from the ears of sweet corn at Brownsville, Tex., by Messrs. D. K. McMillan and H. O. Marsh in December, 1908, and in January, 1909. The pupæ were noticed in abundance in husks and silk. In one case the larvæ and pupæ were taken in moderate numbers in decaying immature corn ears which had been injured by the well-known bollworm or corn ear-worm.

Euxesta thomæ Loew.—The adult of this species issued April 2. It is of about the same size or a little larger than the preceding, but marked much like *Chætopsis ænea* Wied. This species was also reared from the ears of injured corn collected by Messrs. McMillan and Marsh at Brownsville, Tex., December 29, 1908, adults issuing en route January 4 and later. Puparia were found in abundance in the husks and silk. It was associated with the smaller *Ch. ænea.*

From what we know of related species the probabilities are that these three flies live in their larval or maggot stage chiefly on decomposing vegetation but they are all three capable of injuring growing

[a] Bul. 93, Texas Agr. Exp. Sta., pp. 1–16, 1907.

plants. In the case above cited they were quite obviously injurious to the yam tuber, but the extent of the injury was not reported.

Of the three species above mentioned *E. nitidiventris* occurs in Texas and Florida; the other two are apparently not recorded from the United States.

NOTES ON THE FEEDING HABITS OF BLISTER BEETLES.

Entomologists have had occasion to notice, in the case of certain forms of insects, and more especially of gregarious caterpillars, that when once a colony begins feeding on a certain form of plant or other food, a special taste or fondness is developed by that colony and the insects continue on the same material, in the case of caterpillars, at least until about the last stage is reached. The same is observable in the case of leafhoppers, which frequently leave the plant on which they have fed during their first stages of growth and fly to another plant in the later stages. This habit is strongly developed in insects which are omnivorous as well as gregarious, e. g., in blister beetles.

The margined blister beetle (*Epicauta marginata* Fab.) has been repeatedly observed by the writer feeding on beets, literally in "flocks." The beetles begin at some point on a row or two and continue along those rows unless interrupted. When they are more abundant several colonies will frequently strip many rows until entire plantings are destroyed. Not until this is accomplished do they turn to some other food plant. Beet appears to be a preferred food plant of this species when it is available. On one occasion the writer observed this species attacking a row of cabbages contiguous to a row of beets. The beetles continued along this row, evidently "following the leader" like sheep. It is the same with weeds when these are attacked. On another occasion the beetles of this species were observed feeding on lamb's-quarters—not a favorite food—and the flock continued on this plant until it left the neighborhood.

The striped blister beetle (*Epicauta vittata* Fab.) was seen in the same manner eating the rough pigweed (*Amaranthus retroflexus*), which the beetles almost completely defoliated, leaving nothing but the bare stems, and scarcely touching other plants occurring in their line of march.

On such occasions the result is very much the same as though an "army" of army worms had devastated the tract attacked. The army worm supposedly assimilates a large portion of the actual food material which it consumes and which it requires for completing its growth. The blister beetles are already mature and judging from the large amount of excrement which they leave in their wake, consume many times as much as they actually require for sustenance.

While it was the purpose of this note merely to mention the somewhat peculiar habits of our eastern blister beetles, occasion is taken

to add some additional observations. During a trip at Norfolk, Va., in September, 1910, the writer's attention was directed to considerable injury to garden beets and chards. A majority of the insects had disappeared after largely defoliating the plants, but enough remained for an experiment to determine the direction which would be taken by the blister beetles when disturbed, as this has a practical bearing on the driving system practiced so successfully in the Middle West. The margined blister beetle and the black blister beetle (*E. pennsylvanica* DeG.) were present. As many as possible of the beetles were dislodged from the plants, and they were not dislodged at this time with ease, and all thus disturbed, with the exception of one which "played possum," walked away with the wind, as was expected.

Great numbers of the black blister beetle, and small numbers of the sweet-potato blister beetle (*E. trichrus* Pall.), were observed on asters and related plants at Norfolk. From these high plants it was found an easy matter to dislodge the insects, by means of pine switches, into a milk pail containing about half an inch of water and a few drops of kerosene. With a large milk pail and several operators, including children, who readily take to such work, a considerable territory could be covered in a very short time and the blister beetles destroyed before they have time to injure the flowers.

NOTES ON BEAN AND PEA WEEVILS.

The family name Lariidæ has been adopted by European systematists for the Bruchidæ, having been proposed originally by J. Schilsky in 1905. The genus Bruchus of Linnæus, as considered by American coleopterists, is therefore subdivided into other genera. The following notes, including the European nomenclature, are made for the benefit of economic workers:

Laria rufimana Boh.—The broad-bean weevil.
Bruchus rufimanus Boh., Schoenherr, Vol. I, p. 58, 1833.

This species, called also the European bean weevil, has recently been introduced at San Luis Obispo, Cal., from which locality the writer received, through the kindness of Mr. I. J. Condit, collaborator, of this Bureau, specimens reared from the seeds of broad bean grown there.

Laria pisorum L.—The pea weevil.
Bruchus pisorum L., Syst. Nat., 10th Ed., p. 356, 1758.
B. pisi L., Syst. Nat., 12th Ed., p. 604, 1767.

Laria lentis Froelich.—The lentil weevil.
Bruchus lentis Froel., Der Naturforcher, pp. 57, 58, 1799.

The lentil weevil appears to be restricted to the lentil for food. It is well distributed in Europe and is often brought to this country, usually dead or dying, but has not been introduced here to the writer's knowledge.

Bruchidius trifolii Motsch.

Bruchus trifolii Motsch., Bul. Soc. Nat. Moscou, p. 235, 1873.

A very small species frequently received in this country from Egypt in seeds of *Trifolium alexandrinum*, not known to be established in America, but a dangerous species if introduced with its food plant.

Acanthoscelides obtectus Say.—The common bean weevil.

Bruchus obtectus Say, Descr. N. A. Curcul., p. 1, 1831.
Bruchus irrosectus Fahr., Schoenherr, Vol. V, 1839.

Pachymerus chinensis L.—The cowpea weevil.

Bruchus chinensis L., Syst. Nat., 10th Ed., p. 386, 1758.
B. scutellaris Fab., Ent. Syst., Vol. I, 2, p. 372, 1792.

Pachymerus quadrimaculatus Fab.—The four-spotted bean weevil.

Bruchus quadrimaculatus Fab., Ent. Syst., Vol. I, 2, p. 371, 1792.

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